THE GLASS INDUSTRY

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GLASS DIVISION HOLDS TWENTY-FOURTH ANNUAL MEETING DURING A. C. S. CONVENTION

In Pittsburgh, where the Glass Division of the American Ceramic Society was organized 24 years ago, its technical sessions occupied two full days, and set the pace as usual for other divisions at the annual meeting of the Society.

With W. C. Taylor, of Corning, in the chair, and with 100 or more members in attendance at each session, a varied program arranged by J. F. Greene, of Kimble Glass Co., filled all the available time. Discussions were limited only by the clock, and not by lack of interest or willingness on the part of listeners. Perhaps, if those who present papers were willing to abbreviate offerings of numerical data and leave full coverage for later publication, more time could be found for the stimulating and often corrective debate which is the real object of technical sessions.

The method of estimating the expansibility of glass described by S. R. Scholes, of Alfred, depended upon measuring the depression left by the contraction of the glass as it cooled in a cavity in a clay block. While the method cannot be very accurate, it offers promise of exploring that region between strain point and high fluidity, where viscosity is too high for experiments with the suspended platinum ball in finding density.

F. V. Tooley and R. L. Tiede, Owens-Corning Fiberglas Corporation, applied the Turnbull method of centrifugation of powdered glass at high speed and controlled temperatures, in a heavy liquid, to the study of homogeneity —or the lack of it. Apparently, everything that is done in the glassmaking process, from the selection and mixing of the raw materials to the final delivery of the gob to the machine, has its effect upon the way the product approaches ideal homogeneity.

A series of papers by Maurice L. Huggins and Kuan-Han Sun, Eastman Kodak Co., dealt largely with mathematical and theoretical matters. Going beyond the old and oversimplified additive theory, these men gave data, based in part upon measured values, in part on position of elements in the periodic table, from which changes in physical properties could be estimated, even for glasses as yet not studied. Much reliance was placed upon the picture of fine structure as revealed by x-ray studies. This reliance on "Zachariasenism" becomes increasingly popular among the younger workers with glass. Older technologists become a trifle breathless, hurrying to catch up. However, the consistency with which postulates concerned with atomic radii and network formation can be correlated with experimental data points to this theoretical approach to the study of glass constitution as a very useful one. The authors of these papers worked with Alexander Silverman, University of Pittsburgh.

That mysterious region of temperature where glass takes on rigidity before it entirely forsakes fluidity—"Standing, with reluctant feet, where the brook and sliver meet"—was dealt with by Mrs. Aniuta Winter, late of the Institute of Optics, Paris, now with Research Enterprises, Canada. She showed that there is a structural inhomogeneity in glass, independent of internal (mechanical) strain, existing as a result of its failure to arrive at equilibrium for its temperature. The emphasis was upon adjustment of refractive index by heat treatment, and on the fact that the presence or absence of strain is not the whole story. A "transformation region," extending over 100° C. or so, seems to be the critical one in which internal adjustments occur. Dr. John C. Hostetter gracefully complimented Mrs. Winter, as the first woman to read a paper before the Division.

A. R. Tool, Bureau of Standards, continued along a similar vein of ideas, in his paper on molecular strains and thermal effects. He called attention to the real, if slight, endothermic and exothermic effects that occur as glass passes through the annealing range. His calculations for estimating the effects of changing annealing schedules should find practical use.

Old thermometers, whose glass has become accustomed to heating and cooling, are better than new ones. What goes on during aging was ably treated in a paper by Bradford Noyes, Taylor Instrument Co., and N. W. Taylor, Pennsylvania State College.

Just how much eye-protection goggles mean to the production and fabrication of steel and other metals, and hence to the war effort, was not appreciated by the audience until they heard the talk given by E. L. Hettinger, Willson Products, Inc. History, colors, compositions, and heat-treatment were presented in a paper that lost nothing because of its whimsical and half-belligerent style.

J. F. White and W. B. Silverman, Owens-Illinois, made further report upon their phase-equilibrium (devitrifica-

tion) studies. Glasses containing lead oxide came in for attention. Such work is interesting and important because it deals with compositions actually entering much commercial glassware. That "unidentified compound" arouses curiosity which must be restrained.

The paper on viscosity, by H. A. Robinson and C. A. Peterson, was one whose publication will be awaited with interest. It described method and apparatus for handling glasses in the entire temperature range of practice, and the authors seem to have brought the whole procedure of measuring viscosity up to date in a thorough-going manner.

Guessing whether or not heat will penetrate through molten glass when certain coloring elements are present seems to have been eliminated by the studies of H. H. Holscher, R. R. Rough, and J. H. Plummer, of Owens-Illinois. Their data will determine the choice of tank dimensions, or the yields to be expected from a given tank for different color compositons.

A. Herman and H. L. Shay, of Joseph E. Seagram and Sons, conducted experiments extending over three years on the effect of glass bottles on various alcoholic liquors. All of the products gathered faint amounts of alkalinity, proportional to the time, for commercial bottles.

An excellent mathematical treatment of the problem of chemical attack of glasses by water was presented by A. K. Lyle, Hartford-Empire Company. His equation seems to be convincing, when applied to the data of independent researches, and a few moments with a pencil and log table, with data from "accelerated" tests as a starter, may well replace months of waiting for service or storage tests.

When glass-container ring sections are examined under the polarizing microscope, the results should not, like beauty, depend upon the eye of the beholder. Thus argues W. R. Lester, Maryland Glass Corporation, whose committee on standard procedure in such matters has devised a quantitative method of grading. The addition of a quartz wedge for measuring actual birefringence, evaluation in terms of stress, position of cords or other zones of stress, and limits of allowable stresses—considering both tension and compression — are features of the tentative standard method.

T. C. Vaughan, Hartford-Empire Co., showed that flotation of small chips off glass in a heavy liquid could replace older methods of determining density, with a gain in speed and accuracy.

At the luncheon and business meeting on Wednesday noon, 142 men were served—the largest number yet to attend this function. Donald E. Sharp, for the Rules Committee, proposed certain changes, abolishing the provision for members on the Society's nominating committees "A" and "B" (now non-existent) and removing the office of Second Vice-Chairman from the list.

These proposals will go to the Division for letter ballot. Meanwhile the rules were suspended, and the Division ratified the choice of the nominating committee, F. C. Flint, chairman, and elected the following officers: Chairman, J. F. Greene, Kimble Glass Co.; Vice-Chairman, K. C. Lyon, Armstrong Cork Co.; Secretary, S. R. Scholes, New York State College of Ceramics, Alfred.

Prof. Alexander Silverman then read his proposal for the establishment of a glass institute, to be supported by annual contributions from glass manufacturers, and to use existing facilities for the furtherance of cooperative research for the benefit of the industry as a whole. After a brief discussion, the business session was adjourned.

The technical session on Wednesday afternoon was devoted to the discussion of fuels and raw materials as affected by war-time restrictions, and of the "critical and substitute" materials. Some interesting facts and figures were given by A. C. White, Petroleum Economics Division, Bureau of Mines, and by J. R. Hostetter, War Production Board.

Decolorizers and oxidizers, to be used in the absence of arsenic, were the themes of the final hour. W. A. Weyl, Pennsylvania State, treated the theoretical aspects of fining and decolorizing in an interesting manner, showing how and why certain reagents can act as oxygen-carriers in the melt.

The effectiveness of antimony, in replacing arsenic, appears to be still in the "some say this and some say that" stage. The speakers in the symposium showed samples of glass and cited specific instances of success and failure with antimony. No decisive conclusions were reached.

At the close of the session, Committee C-14, A.S.T.M., held a brief meeting for appointment of new sub-committees and hearing reports. Formal vote was taken on five tentative standards, ratifying the letter ballot advancing them to the standard rank.

In the scope and character of the papers presented, and in the large attendance and sustained interest of the members, this meeting was one of the best in the long and successful history of the Glass Division. A solemn note marked the proceedings on Tuesday morning, when a minute of silence was observed, in memory of A. N. Finn, one of the oldest and most active and respected members, who died during the past year.

Five members of the Society were elevated to Fellowships during the Meeting. They are: W. L. Fabianic, Sanford Stoddard Cole, Fred W. Shroeder, Robert Anderson Miller and Jacob Ellis Rosenberg.

J. F. Greene

Factors Affecting the Degree of Homogeneity of Glass. *By Fay V. Tooley and R. L. Tiede, Research Laboratories, Owens-Corning Fiberglas Corporation.*

The authors have studied the rate of homogenizing of a soda-lime-silica glass under conditions of minimum convection mixing and in the absence of contaminating refractory materials. Melts were made in pure platinum containers at 2550°F and at specified time intervals samples were taken for the measurement of the danger of cordiness. This was measured by the use of the centrifuge density spread technique developed by Turnbull and Ghering. It was found that the density spread decreased very rapidly during the first 16 hours of meeting after which the decrease was at a very much slower rate. The portion of the glass responsible for the major part of the total density spread was found to be a light fraction and that this light fraction tends to form or accumulate at the surface of the melt.

Optical Fluor-Crown Glasses. *By W. A. Fraser and L. O. Upton, Bausch & Lomb Optical Company.*

While the amount of Fluor-crown optical glass used is small such glasses have very important uses in certain types of optics. The present investigation was therefore carried out in order to study the effect of variation of composition on the optical properties of such glasses.

In the experimental meltings much trouble was experienced in finding a fluorine-bearing chemical that would be suitable for introducing the fluorine into the batch. Calcium fluoride, as well as other divalent elements were not suitable due to their tendency to produce opalescence. Sodium fluorides and potassium fluoride for various reasons were also not suitable. A satisfactory combination for the purpose has been found.

Measurements of the optical properties of the experimental glasses showed that alumina and fluorine when substituted for silica lower the index of refraction, alumina reduces the reciprocal dispersion while fluorine raises it, boric oxide has no appreciable effect on either the index of refraction or the reciprocal dispersion and that fluorine and alumina can be balanced against each other to produce any desired optical property in the field of glasses studied.

Surface Layer of Sheet Glass. *By F. L. Bishop, Jr., American Window Glass Company.*

In an effort to obtain some information on the nature of the fire polish on sheet glass the author has studied the surface layer of sheet glass by three methods, 1—measurement of the deviations from Fresnel's reflection laws, 2—comparison of the apparent Brewsterian angle with that calculated from the index of refraction of the glass and 3—the measurement of the true index of refraction by a prism method.

It was found that a freshly drawn sheet glass has a crystalline layer several molecules thick on the surface and that this layer has a high index of refraction but is counteracted quickly by water absorption if the glass is dampened slightly or exposed to the atmosphere.

Standard Method of Examining and Grading Glass Container Ring Sections. *By W. R. Lester, Maryland Glass Corporation.*

A standard method of examining and grading glass container ring sections has been proposed by the Technical Committee of the Glass Container Association. The method represents an attempt to eliminate the personal factor which characterizes the procedures now in use. Details such as frequency of test, sample location, method of cutting and equipment have been standardized.

The proposed method of examining and grading ware quality is in brief as follows: the locations of the greatest tensile strain in, 1—the interior of the specimen, 2—the outside surface of the specimen and 3—the inside surface of the specimen are found by the use of a tint plate and the amount of stress present is then measured by the means of a graduated quartz wedge or through the use of a color-stress chart (for approximate work). The interior stress is multiplied by 1/3, the tension stress on the outside is multiplied by 1 and the tension stress on the inside surface is multiplied by 2/3. Whichever of these figures is the largest is taken as the ware quality index and is an indication of the relative ruggedness of the ware insofar as it is affected by the inherent strains.

A Method for Estimating the Expansibility of Glass at High Temperatures. *By S. R. Scholes and Kurt Mooney, N. Y. State College of Ceramics, Alfred University.*

Cavities about ¾″ by 4″ deep are formed in a fireclay block. These are filled with molten glass, to overflow at the high temperature. Upon cooling, the glass contracts and forms a depression whose volume can be measured by filling with water from a buret. From the measured capacity of the cavity, after correction for the contraction of the clay body, the change in volume of the glass between the high temperature and the strain point can be estimated.

The expansion of a container glass between 900° and 2550°F. amounts to 12 per cent by volume. Less than 4 per cent expansion was found between 900° and 2100°, and a rapid increase in rate of expansion between 2000° and 2300° seems to take place.

Aging Thermometers. *By Bradford Noyes, Taylor Instrument Companies, and Nelson W. Taylor, Dept. of Ceramics, Pennsylvania State College.*

Glass, when annealed so that the polariscope no longer shows strain, may still continue to undergo a change in density or volume. At room temperature this change is slow but measurable, at higher temperatures it is more rapid. In the case of thermometer bulbs the contraction causes the readings of a fixed point such as the ice-point to rise gradually over a long period of time. Eventually the process ends, and the glass is said to be stabilized.

In the manufacture of thermometers it is desirable to artificially age the instruments in such a way that subsequent changes will be reduced to a minimum. This is accomplished by giving the glass suitable heat treatments. A thermometer may then be held at constant temperature and its behaviour studied. In general, the change in readings, y, will follow an exponential curve whose equation is $y = a\,(1\text{-}e^{-mt})$. The ultimate change a, the relaxation time, 1/m, and the "half-life period," H 0.693/m, may be readily determined. Methods for evaluating these quantities are given by the authors. Calculations are also made to show the change still to be expected after any particular aging time. The method is highly sensitive, since a change of 0.1° corresponds to a change of one part in one hundred thousand in the density of the glass. It is believed that the exponential law is due primarily to bulb shrinkage under the influence of a single molecular mechanism in the glass.

Some examples are presented of anomalous behavior, such as reversals in the direction of change. This phenomenon is shown to be a general one in glass, and an interpretation is given in terms of several molecular processes which operate at one time but with different characteristic rates.

The methods of analysis described in this paper are useful for evaluating the effects of accelerated aging treatments on other glasses as well as thermometer glasses, for example, optical glasses, volumetric apparatus, glass gauges, and other products where volume stability is essential.

Method for Computing Approximately the Changes Caused in Glass by Annealing. *By Arthur Q. Tool, National Bureau of Standards.*

During production it is often necessary to change the annealing schedule when fine-annealing optical glass. As density and refractive index depend upon the annealing schedule followed, such changes may adversely affect these

properties and in addition the new schedule may or may not result in an adequate reduction of the strain present. Dr. Tool described a method, which, by its use, allows one to compute the effects of any change in the annealing schedule. Why the results of the computation are only approximate they do serve as a guide whenever a change in schedule is undertaken and are particularly useful in those cases where a single supplier of, for example, optical glass blanks to several different molders using different annealing schedules. In addition, the computed results allow one to obtain an insight into the manner in which changes in density and refractivity develop and strains relax.

Devitrification Characteristics of Alkali-Lead Oxide-Dolomite Lime Silica Glasses. *By J. F. White and W. B. Silverman, General Research Laboratory, Owens-Illinois Glass Company.*

Lime crystal glasses (alkali-lead oxide-lime-silica glasses) find considerable use in the production of tableware. As such glasses are usually melted in pots and worked by hand they must have a long working range and a low liquidus temperature in order to minimize devitrification during the forming operations. The present investigation deals with a study of the liquidus temperatures and the devitrification products of a series of glasses in the lime-crystal field.

The glasses under investigation were melted in large platinum crucibles from commercial raw materials. Homogeneous glass was obtained by crushing and remelting and by stirring during melting. The liquidus temperature was then determined by the temperature gradient method which in brief consists of bringing to equilibrium a glass which is subjected to a uniform temperature gradient from a temperature above its liquidus to another considerably below it. A temperature probe of the furnace is also made. The primary phases are identified by microscopic examination of these sections of the glass so treated.

Phase diagrams were then drawn and the various devitrification products, boundaries, and liquidus isotherms shown and discussed. It was concluded that 1—glasses containing 16 per cent total alkali and more than 8 per cent lead oxide will have liquidus temperatures sufficiently low that they may be used for the commercial production of lime crystal glassware, 2—replacement of SiO_2 by CaO. MgO is much more effective in reducing the liquidus temperature than is replacement of SiO_2 by PbO, and 3—K_2O is sometimes effective in reducing the liquidus temperature when it replaces Na_2O.

Viscosity of Recent Container Glass. *By H. A. Robinson and C. A. Peterson, Armstrong Cork Company.*

In order to study the relationship between the viscosity of commercial glasses and the actual manipulation of the glasses in machine forming operations the authors have constructed two viscometers, one based on the rotating cylinder method and the other using the fibre-extension method. The two viscometers were described in detail and results obtained on standard glasses and from comparisons with the results of other investigators indicated that the equipment yielded highly reproducible results throughout the entire temperature range usually encountered.

Sixteen current container glasses were investigated and there complete viscosity temperature data and complete chemical analysis were obtained. The data was analyzed and it was found that in all cases a Fulcher type equation, $\text{Log} = \frac{B}{-A-To}$ would fit. The curves of the commercial glasses indicated that the spread between the most viscous and least viscous was not excessive and that all of the glasses were quite similar in viscosity behavior.

Experimental Studies of Temperature Gradients in Glasses of Various Colors. *By H. H. Holscher, R. R. Rough, and J. H. Plummer, General Research Laboratory, Owens-Illinois Glass Company.*

By using a small model furnace in which the glass is heated over the top glass surface and the temperature of which was held at 2615°F the authors have investigated the vertical temperature gradients existing throughout the depth of glass and the effect of various coloring agents such as ferrous iron, ferric iron, manganese, cobalt, chrominum oxides and iron chromate on the temperature gradient. Using the temperature gradient of flint glass as a base it was found that cobalt decreased the temperature gradient while iron, manganese and chromium increased the temperature gradient. The data obtained has great importance when comparing the maximum melting capacities of commercial furnaces as they indicate the over-all heat transmission to the various colored glasses at various depths.

The authors also obtained data on the temperature gradients existing in commercial flint, amber and emerald green furnaces by inserting a long water-cooled thermocouple through the crown of the furnaces until the couple touched the glass surface. Temperatures were then taken at various depths of immersion. It was remarked that due to the difficulty of obtaining data in this manner the results are not very accurate. However, comparison of the temperature gradients obtained in this manner with those obtained by the laboratory method showed very good agreement.

Effects of Glass on Alcoholic Products Stored in Bottles at Room Temperature for Three Years. *By A. Herman and H. L. Shay, Joseph E. Seagram and Sons, Inc.*

This study was undertaken in an effort to correlate the results of accelerated durability tests with actual storage conditions and also to determine to what extent various types of alcoholic liquors during storage at normal conditions.

The bottles used were from the same lot previously used in the study of accelerated durability tests and were filled with seven different types of alcoholic liquors and were stored at room temperature for a total period of three years. Pyrex flasks were used as controls. At twelve month intervals the test bottles and pyrex flasks were examined and the pH of the products determined by the means of a Leeds and Northrop potentiometer. At the end of the three-year period spectroscopic studies were made on both the test samples and the controls.

It was shown that with the seven products studied, three years storage in pyrex flasks did not materially affect the original pH of any of the products but that the pH changes of the products when stored in commercial bottles are inversely proportional to the chemical durability of the glass which is expressed in milligrams per liter of sodium hydroxide. The results obtained by the spectrographic study indicated various degrees of metallic contamination as compared with the photograph made from the same product stored in pyrex glass. The spectrograms showing the presence of dissolved silica, magnesium and aluminum in both neutral grain spirits and gin which had been stored in commercial glass bottles.

Determination of Density by a Flotation Method. *By T. C. Vaughan, Hartford-Empire Company.*

The procedure used for the rapid and accurate determination of the density of glass by a simple flotation method was described by Mr. Lyle. In brief the method consists of adjusting the composition of a heavy liquid until its density matches that of the glass sample (sample size being from 10 to 40 mg.). The density of the matching liquid is then determined by the use of an accurately calibrated standard. Results obtained by the use of this procedure were given and showed that it was quite accurate particularly when it is considered that only small chips of glass are used.

Eye-Protective Glasses Go to War. *By E. L. Hettinger, Willson Products, Inc.*

Talk based on thirty years of experience in eye-protective glass field, starting with World War I which cut off foreign sources of supply for this material and necessitated development of domestic source of supply. It is significant that the hardship imposed by World War I enabled American glass makers to produce the eye-protective glasses that play such an important part in World War II on the industrial front as well as the actual fighting front.

Mention was made of some of the trials and rtibulations encountered in the early days when many men knew how to make pretty colored glasses but knew practically nothing about the elimination of the harmful rays. The difficulties and problems of mass production of iron glasses was briefly mentioned.

Of the various slides shown, those described below had one or more outstanding facts:

One showed by comparison of cutoffs at the various lines that a ferrous oxalate batch produced a glass superior to an ordinary iron oxide batch, which costs less money. This higher manufacturing cost naturally increases the retail price. The ferrous oxalate is far more expensive than ordinary iron oxide.

Another slide showed the development of iron glasses as compared with sky blue, blue, amethyst, smoke, amber, fieuzal and chartreuse.

A special blue glass with an extremely good cutoff at the 579 line, or high yellow caused by sodium flux, making it especially good for gas or aluminum bronze welding. Superior to ordinary didymium glass because of its high cutoff in ultraviolet and infrared. ***

Slide of National Carbon Co. therapeutic spectrum was shown to refresh the memory of the various lines and fields.

Excellent infrared and ultraviolet cutoff of Willsonite smoke or smokite and amberite as compared with ordinary smoke and amber both of which transmit about 70 per cent infrared—and smoke transmits about as much ultraviolet. These new glasses have excellent eye protective qualities far superior to the routine shades.

***The blue (alubro-weld) has a special color psychology value, having a definitely clear and pleasing cut-down of the high yellow, whereas, an iron didymium gives a rather muddy effect. It has been found on all welding jobs that the retina must be adapted to the volume of light to get depth of perception to be able to follow the flow of metal from the welding rod; the puddling or metal deposit must always be under control. Too much deposit requires grinding off and too little makes a weak joint.

Another slide showed the results of several hours exposure to the spatter on a welding operation on a clear cover glass and a clear coated cover glass, which are used to protect the more costly welding glass in welding helmets or handshields. No particles adhered to the coated glass but the ordinary glass had a thick deposit of metal making it unfit for further use. The same thing will happen to a pair of unprotected spectacles on an emery grinding wheel operation.

Changes of Properties of a Glass Resulting from Changes of Composition. *By Maurice L. Huggins and Kuan-Han Sun, Research Laboratories, Eastman Kodak Company.*

In previous papers, Huggins and Sun have given methods for the calculation of the density and various optical properties of a glass from its composition, expressed in weight percentage. In the present paper the authors present a general method for the calculation of the changes in density and optical properties of a glass when a small amount of a given oxide is added to a glass of known composition or properties or is substituted for another component already present in the glass. The equations to be used were given and their derivation described. Values have also been computed and listed for the initial fractional rate of change of refractive index when various components are added to (a) pure SiO_2 and (b) a sodium silicate glass containing 50 weight per cent Na_2O.

Glass Properties and the Periodic Table. *By Maurice L. Huggins and Kuan-Han Sun, Research Laboratories, Eastman Kodak Company.*

The authors have presented a series of graphs showing the variation of certain constants, characteristic of oxide components of glasses, with the position in the periodic table of the more metallic element of the component. The magnitude of the constant being plotted against the atomic number, points for oxides of elements in the same sub group were connected using broken lines if the consecutive points do not represent consecutive elements in the sub group. This graphical arrangement shows very clearly the relative effect of different components on certain properties (volume constants, specific volume constants, refraction constants and dispersion constants) of glasses, whether simple or complex in composition. The curves also enable one to obtain a rough estimate by interpolation and extrapolation of the values for components for which experimental data are not at present available.

The Vitreous State. *By Maurice L. Huggins and Kuan-Han Sun, Research Laboratories, Eastman Kodak Company and Alexander Silverman, Department of Chemistry, University of Pittsburgh.*

A rigorous definition of a vitreous substance is quite difficult and it would seem that the term "vitreous" should be considered only as a convenient descriptive adjective due to the many border line cases that are encountered. The various theoretical requirements which a substance must meet if it is to be considered vitreous were discussed in detail and included silicate glasses, vitreous sulphur and selenium, silica various oxide glasses, glasses containing hydrogen bridges and organic polymers.

Molecular Strains and the Extraordinary Thermal Effects in Glasses. *By Arthur Q. Tool, National Bureau of Standards.*

From the results of various studies and measurements made on the delayed or extraordinary volume contractions and expansions that take place in annealing and in disannealing glasses, respectively, and also on the accompanying extraordinary heat evolution and absorption, it appears that the quantities of heat evolved and absorbed have the same order of magnitude as the heat equivalents of the work done by and against the enormous "intrinsic pressure" as glass contract and expand extraordinarily. These results, coupled with the random network theory were discussed by Dr. Tool and an attempt was made to correlate these extraordinary thermal effects with the gradual relaxation of molecular strains that presumably are developed with every temperature change in highly viscous liquids such as glass and other materials of cellular-like and random structure arrangement.

Theoretical Aspects of the Chemical Attack of Glasses by Water. *By Aaron K. Lyle, Hartford-Empire Company.*

By considering the chemical attack of glasses by water as being a diffusion phenomenon in which the rate of release of soluble matter from the glass is slow compared to its rate of diffusion in the attacking medium, the author has been able to show that the effects of time and temperature on the chemical attack of glasses by water can be represented by an equation of the following type: $a \log N = \log \theta - \frac{b}{T} + C$, where N is the attack, θ is the time, T is the absolute temperature °K, and a, b and c are experimentally determined constants. The constant b was found to be a universal constant, being independent of the glass composition and of the size and shape of the sample. For tests of ordinary glass containers the constant b was found to have a value of 5080.

The equation may be simplified to a time-temperature formula in which case it takes the form: $\log \theta = \frac{b}{T} - C$, and then becomes useful for estimating the storage or service conditions equivalent to an accelerated test, or it may be used for calculating the conditions for alternate tests.

The accuracy and usefulness of the equation was demonstrated by applying it to data taken from the literature. In the case of attack by water very good agreement was found between the calculated and observed results. With acid and alkali attack some agreement was found but in these cases the rate of attack seemed to be influenced by the strength of the test solutions and the effect of temperature seemed to be more complicated than indicated by the developed equation. (*Continued on page 226*)

Ceramic Camera Club

Prize Winners 1943

"Still Life" by F. G. Schwalbe
The Frazier Award. First Prize, Pictorial

"Old Ned" by Robt. W. Knauft
Honorable Mention, Portrait

"Glass-Water and Steam" by Dr. C. L. Babcock
Honorable Mention, Industrial

"Bueno" by J. Earl Frazier
First Prize, Portrait

"Industrial Rhythm" by J. Earl Frazier
First Prize, Industrial

"Winter Shore" by Rolland Roup
Honorable Mention, Pictorial

Research Digest

Practical Interpretations of Glass Technology

Fluorescence of Glass

Weyl (Industrial Engineering Chemistry, September, 1942) has presented an excellent review on the subject of the fluorescence of glass which deals with both the theory of glass fluorescence and the practical application of the fluorescence phenomena of glasses. Weyl shows how the fluorescence phenomena can be utilized for (1) practically as a product identifier and as a so-called "tracer material" for studies on glass melting processes, (2) as an optical indicator for theoretical studies on the atomic structure of glass and the effect of heat treatment on structure, and (3) the more important commercial application, that is, its use in the production of so-called cold light sources, specifically fluorescent lighting.

Item 1 is of direct interest to those engaged in the manufacture of glass as it is shown that materials capable of exhibiting fluorescence when incorporated into the glass (but which do not impart a visible color to the glass) can be used for identifying a glass from competitive products. Likewise, additions of fluorescent materials, such as cerium oxide, can be used for studying flow conditions and flow speeds in the furnace. Cerium containing glasses when placed under ultra-violet light emit a strong blue fluorescence, but yet are colorless and therefore do not upset production as do other tracer materials that have been used in such studies.

In theoretical studies of structure, fluorescent ions such as uranium UO_2^{++} or europium, Eu^{+++}, are introduced into different base glasses and their emission spectra studied. Comparison with their effect on crystaline materials of known symmetry and atomic arrangements allows one to draw conclusions regarding the atomic structure and constitution of the glasses.

Weyl also suggests a classification of fluorescent glasses which arranges them according to the role played by the vitreous phase in producing fluorescence: fluorescent enamels containing crystalline phosphors (Lenard type), fluorescent glasses containing crystalline residues on which the activator is absorbed (Fisher type), fluorescent glasses containing atoms or molecules in an "energetically isolated" state, and glasses containing cations or auionic groups as fluorescence centers.

The quenching of fluorescence in glass is also discussed and may be due either to (1) temperature, which when increased impairs the fluorescence and vice versa; (2) concentration, which when it exceeds certain critical values decreases fluorescence (for example in the case of cerium, 2-3 per cent presents the optimum concentration); and (3) foreign atoms, which in the case of glass iron seems to be the worst offender as far as quenching of fluorescence is concerned.

The Fluorescence of Manganese in Glasses and Crystals

In the Journal of the Optical Society of American (August, 1942) Linwood and Weyl show how ions of the transition elements can be used as optical indicators in studies of the atomic structure of glass and its rearrangement with heat treatment. Divalent manganese is insensitive as a color indicator but is very sensitive when its characteristic fluorescence under ultra-violet is utilized. Manganese, when present in either glasses or crystals gives bright red, green or intermediate fluorescent colors. Previously the emission color changes were thought to be due to Mn^{++} and Mn^{+++}, but the authors show that they can be correlated with shifts in oxygen coordination of the Mn^{++} from four (green) to six (red) which is also comparable to the absorption color changes of nickel and cobalt. This was confirmed by comparing the fluorescence of manganese in different types of base glasses with the blue (fourfold coordination) to pink (six fold coordination) transition of cobalt and also by comparing the relative effects of temperature on the green and red fluorescence. The green being more susceptible to quenching when the concentration was increased, the fluorescence disappearing when every tenth Si^{4+} was replaced by Mn^{++}. In the case of the orange and red fluorescing glasses, MnO could be introduced in amounts up to 15 per cent, the limiting concentration not being due to quenching but to devitrification.

The fluorescence colors of crystalline phosphors are explained from the viewpoint of crystal chemistry, yellow fluorescence obtained with some manganese activated zinc silicates is shown to be due to a cristobalite structure while in the case of willemite, the manganese is surrounded by four oxygens to give green.

The influence of imperfections in the crystal structure on the fluorescence of manganese is also described.

Fitting Glazes to Ceramic Bodies

While the paper by Schurecht (Journal American Ceramic Society, March, 1943), deals in its entirety with the subject of glaze fit on white ware bodies, several of the methods for determining stresses between the glaze and the body which are described, seem to offer interesting approaches to the solution of certain glass problems such as the measurement of cord stress and in the case of decorated ware the measurement of the stress is between the glass and the glass enamel color.

Cord stress in transparent glasses is usually measured by either a sensitive tint plate using a color scale for the calculation of the amount of stress present or by a graduated quartz wedge. With the quartz wedge the displacement of the black line is oftentimes difficult to measure. Schurecht suggests the use of a Berek compensator which is inserted in the tube of the microscope and rotated until extinction occurs and the stress calculated by the following formula:

$$F = \frac{\Delta}{2.6\,E}$$

F = stress (Kg. per sq. cm.).
Δ = optical path difference (μ).
E = Thickness (cm.).

(*Continued on page* 226)

FOREIGN OWNED GLASS PATENTS AVAILABLE FOR FREE LICENSING

A Supplement to those summarized in the March issue of The Glass Industry

Editor's Note: The inventions covered by these U. S. patents have been made available to the glass industry through a supplemental vesting order of the Alien Property Custodian. A licensing program has been established for the purpose of removing barriers to America's war-time industries by putting these inventions to work. Some details of this program were outlined in the March 1943 issue of The Glass Industry. For complete information correspondence should be addressed to the Alien Property Custodian, Chicago, Illinois.

Furnaces:

To produce colored glass in a side duct from a clear glass tank, Pierre Brosse of Paris (S. A. Holbrever) describes in 2,115,408, the apparatus of Fig. 1. Clear glass being led toward the machine feeder at the right receives coloring matter through the top at 2, and passes rotary stirrers 6 which aid in homogenizing the colored glass. The process is aided by the damper walls 14 and 16 and by additional heating.

Louis Boudin's patent 1,960,136 provides a gate for obstructing the flow of glass to a forehearth when it becomes necessary to cease drawing.

Patent 1,892,462 to Eugene Gentil of Paris claims the method of controlling the heat conditions in a melting furnace which includes housings which maintain constant pressure outside of the ports in spite of atmospheric variations.

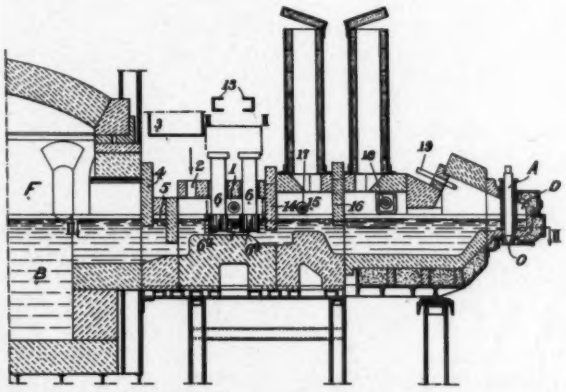

Fig. 1. 2,115,408: Brosse. Clear glass from the tank furnace receives coloring matter and is homogenized while moving through the duct to the feeder.

Societe Quartz and Silice Fused Silica Patents:

The important group of fused silica patents controlled by S. Quartz & Silice, of Paris, France, seized by the Alien Property Custodian, represents the patent structure based on the technical developments of Henri George, Pierre La Burthe and Gaston Delpech. The five patents granted to George include 1,583,229, expired May 4, 1943, covering the direct machining of a fused silica cylindrical blank formed by fusion around a carbon core. In a later patent 1,601,523 he melts silica in a cylindrical furnace heated by a high frequency induction coil, and then extrudes it through the bottom for working, by air pressure exerted against the top of the fused mass. In place of the process where silica is fused around an electrode to form an ingot, later to be reworked, George replaces the electrode with a carbon mold (1,612,628) having the approximate shape of the desired product. The mold is raised to the temperature necessary to melt the heaped charge by high frequency induction. He reports in patent 1,755,953 a method of using special quartzites instead of rock crystal. The quartzite must of course have high purity, and should be finely crystalline and free both of cementing material and substantial amounts of occluded gases. Such rock is utilized by packing large chunks embedded in pure sand into a melting chamber. After the mass is melted the chunks are examined for transparency. The best ones are utilized for optical purposes after cutting and polishing, and others are worked over.

La Burthe tells in 1,724,844 how a fused silica article can be changed in shape by fusing additional material to it. For example a base can be fused to a vase or a ring to a cylinder. The method is to pack pulverized silica around the blank and to place the assembly within a coil where fusion between the blank and the added material takes place. A La Burthe-Delpech patent 1,777,206, gives a good exposition of the art of hot-stamping articles from masses of natural or pre-fused quartz heated above 2200°C.

In another La Burthe patent 1,868,421 means are described for freeing pressed quartz articles of the layer of sand which is present on the outer layer of blanks obtained by the orthodox method of melting silica around a carbon electrode. The mold is accordingly provided with small drilled cups into which this sand escapes as the article is pressed into the mold.

The Delpech patents include 1,857,080 for silica articles with a glazed surface and 1,894,853 for means of drawing fused glass tubes. According to the former, articles such as crucibles are blown in a mold having approximately the desired shape, and then are reheated while held just above a mold face having the desired shape, the heating being continued until the glass sags into shape against the mold from which it takes its glazed surface. The tube drawing process is similar to those commonly known for drawing glass through an orifice and over a mandrel. Delpech's patent 1,848,940 describes apparatus for molding articles which can advantageously be blown from a tubular blank of silica glass. A tube long enough to make several of the articles is lowered through an electric furnace and directly into a mold under the furnace so that the heated section can be blown to shape by air passing down through the entire tube.

In addition to the foregoing group of patents assigned to S. Quartz & Silice, Mr. Delpech assigned others of similar subject to S.A. des Mfg. des Glaces & Produits Chimiques de Saint-Gobain. Patent 2,018,056 describes

a method of finishing fused quartz articles by grinding the surfaces of the shaped articles while their temperature exceeds 300°C, and 1,992,994 concerns a continuous melting process.

Roirant's Bottle Patents:

One of the largest groups of seized patents consists of ten bottle machine patents issued to S.A. d'Etudes et de Constr. d'Appareils Mécaniques pour la Verrerie. The seventeen year life of 1,579,396 covering an automatic machine for blown glass containers has expired since the patent was seized, but others were issued as recently as 1938. In the suction device of 1,615,886 the gathering mold moves toward the interior of the furnace after picking up a charge. The forming machine of patent 1,671,997 has two suction gathering parison molds which dip by turns into the forehearth. In forming bottles with pushed up bottoms, as shown in Fig. 2 from patent 1,888,393, the bottom of the finishing mold drops slightly after the bottle has taken a normal shape. This allows the bottom of the bottle to sag into contact with the mold bottom and, by stretching, to get rid of the area of thicker glass in the bottom of the mold; a pusher is then substituted for the original mold bottom section and it then presses the glass inward to give the final push-bottom shape. Patent 1,946,411 describes a type of finishing mold in which the blowing of the parison to final form is by means of a vacuum produced between the parison and the interior walls of the mold. Patents 2,023,745 and 2,023,746 cover forehearths whose rotation is so synchronized with movement of the gathering molds as to minimize the possibility of chilled glass being drawn. Automatic container machines are discussed in patents 1,873,788 and 2,021,670. In the latter the machine comprises two drums, one carrying parison molds and ring molds synchronized with the second drum providing finishing molds. At the end of each rotary movement the first drum moves downward while the others remain at the same level, and at this interval the parison is transferred to the finishing mold through the medium of the ring mold. In Roirant's latest patent 2,134,342 the problem of making such large containers as carboys has been attacked and his solution is a machine with a number of parison molds all feeding but one finishing mold. The advantage he believes are that this prevents over-heating of the parison molds due to the greater mass of glass in such ware by giving them a longer resting period, and that the finishing mold is advantageously allowed to become hotter.

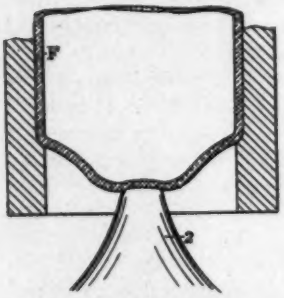

Fig. 2. 1,888,393: Roirant. In forming pushed-up bottom containers the bottom of the container is allowed to sag before the push-up.

Forming Glass Tubing:

In the group of glass tube patents assigned to Maatschappij tot Beheer en Exploitatie van Octrooien, The Hague, are three issued to Leopoldo Sanchez-Vello and one to Leander N. Pond of Corning, N. Y. In 1,975,737 it is revealed that when tubing is formed by drawing it over a mandrel through which the blowing air is provided, air bubbles are kept from the glass by having a vacuum chamber back of all glass-contacting surfaces in the drawing zone. Pond's patent 1,951,993 relates to the same process and provides take-off rolls of such a design as will give the tubing a slight rotation or twist. In patent 2,009,326 for other variants of the method of flowing glass through an orifice and around a mandrel, provision is made for enlarging below the orifice the diameter of the tube and then drawing the enlarged tube to a diameter less than that of the orifice. The fourth patent covering similar methods, 2,009,793, provides for rotation of the mandrel and of the tube as it is drawn. This rotation of the tube is said by E. L. Coultre of Paris in patent 1,926,905, to be essential for uniformity and succesful drawing in cases where, as in the above processes, the glass flows vertically by gravity and then is drawn to a horizontal plane. He states that he is able to obtain rotation by heating the tube along one vertical just below the orifice which it is drawn.

A quite different tube forming process is illustrated in Fig. 3 from patent 1,869,303 issued to J. A. Cardot, assignor to S. A. le Pyrex, Paris, France. Glass entering a pot through a submerged orifice 5 is shaped internally to tube form by means of a rotating tool 6, and then is drawn to give proper caliber and wall thickness.

In still another tube forming patent, Jules Arrault of France (1,941,925 to S. A. des Mfg. des Glaces & Produits Chimiques de Saint-Gobain) tells how the flow of glass to the drawing chamber of a Danner machine can be governed by a meter which calipers the diameter of the product.

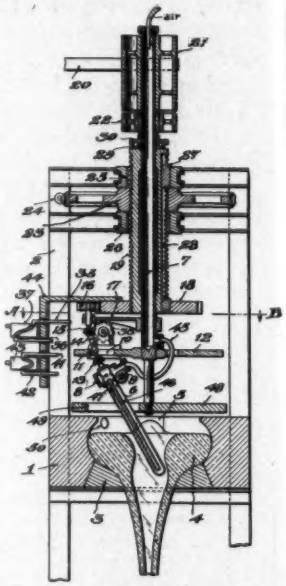

Fig. 3: 1,869,303: Cardot. Tubing obtains its initial internal shaping from a rotating tool 6.

Miscellaneous Forming Patents:

Patent 1,580,076, already expired and 1,586,462 expiring May 25, 1943 were granted to Jean Paisseau of Courbevoie, France for the manufacture of beads from a rod of glass melted in a blow pipe.

A mold for casting glass insulators with an internal loop is described in patent 1,754,101 issued to H. L. J. Haquin of Voyenne, France.

Patent 2,276,399 to Vaclav Hrdina, of Chlum, Czechoslovakia, concerns a process of making stemmed tumblers by conveying glass to the mold by a blow pipe and blowing and sucking on the glass simultaneously, the suction being applied through vents at the base of the stem.

A machine for making vials from tubular blanks is

described in patent 2,002,432 granted to Léon L. Comoy of Paris.

Patent 1,971,110 granted to Leon Lhoest of Antwerp, Belgium, covers a rotary transferring apparatus for handling incompletely solidified bottles taken from a partible blow mold.

Patents 2,025,581 and 2,020,462 granted to Etienne Féchoz of Gilly-sur-Isere, France, concern a forehearth construction and an automatic bottle machine of the suction feeding type. Means are provided for circulating the cold glass shearings in the forehearth so they will be returned to the tank and not picked up by the machines.

Vertically Drawn Sheet:

In drawing apparatus of the Fourcault process René Arcq of Brussels in 1,846,984 provided auxilliary rollers solely for the purpose of bearing against the edges of the sheet and holding the sheet against sliding sidewards or backwards. These rollers are free to roll only in the direction of draw.

Rudolf Thum of Czechoslovakia provided in patent 1,868,858 a rotating refractory roller extending across the tank and half immersed in the glass so that glass moving toward the drawing chamber was required to pass over it in a thin layer to aid in obtaining homogenization.

Ernest Delacuvellerie of Brussels designed elastic deformable rollers for vertical drawing which were made up of numerous rings turned frictionally by powered shafts within them, (2,231,857). His patent 1,582,132 for methods of controlling the temperature of glass for vertical drawing expired April 27, 1943.

To overcome chilling which might cause devitrification between the furnace walls and the normal drawing device of the Fourcault process, electrodes for supplementary heating are arranged in a number of ways by E. V. Borel in 2,236,231 assigned to S. A. des Mfg. des Glaces et Produits Chimiques de Saint-Gobain. Patent 2,263,493 formerly controlled by the same group was issued to Louis Habert of Paris for the apparatus of Fig. 4 for obtaining close control of a vertically drawn sheet by providing rollers at the point of draw for keeping the glass constantly flowing toward the meniscus. The glass moving downward between the rolls is used for cullet. Other patents of the same assignee's are 2,085,575 and 2,120,435 issued to Louis Desbordes and Pierre Bertrand for improved drawing rolls in which the usual asbestos discs which are slipped onto steel tubes, are given high compression at their outer faces so as to reduce wear.

Patents 1,795,254 and 1,805,329 issued to Paul Escole of Jeumont, France (Ateliers de Construction & Fonderies de Jeumont) are concerned with improved and more sensitive suspension devices for the driven rollers of appartus for drawing sheet glass.

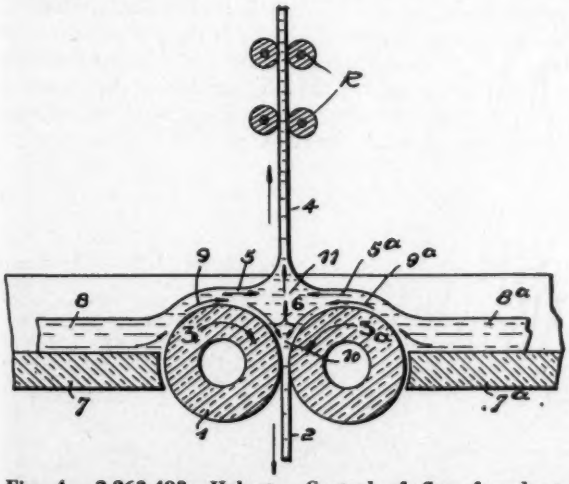

Fig. 4. 2,263,493: Habert. Control of flow for sheet drawing is secured by governing speed of rolls 3 and 3a, from which the surplus sheet 2 is used for cullet.

Horizontally Drawn Sheet:

Patents 1,654,784, 1,859,862, 2,052,212, 2,122,083 and 2,167,290 represent a group granted to Louis Boudin of the S. A. des Mfg. des Glaces & Produits Chimiques de Saint-Gobain. Each is concerned with apparatus for flowing a sheet of glass through a weir in the side wall of the furnace by which it is delivered to rolls. In the first patent there is a heating chamber between the weir and the first rolls. In the second there is a forming pass outside the weir to compact the stream before it reaches the rolls. In the third the restriction which reduces the glass depth in the forehearth to such a layer as can be handled by rolls is produced by a throttling bar which extends downward into the bath. In patent 2,122,083 the horizontally drawn sheet passes from the first rolls onto a corrugated table which produces corrugated sheet. The last patent in this group provides a degree of forehearth control by the means of Fig. 5, wherein is shown a movable partition which divides the forehearth into two zones, one within and one outside the furnace.

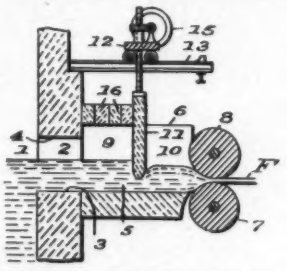

Fig. 5. 2,167,290: Boudin. Partition tile 11 is movable so forehearth area may be modified.

The same company was assignee of A. D. H. Chan's patent 2,184,908 for means of controlling the temperature of metallic rolls by applying brushes or similar metallic elements to their surfaces and removing or supplying heat through them.

Charles Heuze of Auvelais, Belgium in patent 1,675,217, describes a process of making sheet by storing a mass of molten glass in a forehearth trough from which it flows up under the pressure of its hydrostatic head to flow between rolling cylinders.

Brancart Plate Glass Patents:

Twelve patents granted to Yvon Brancart of Ronquieres, Belgium, for plate glass cast onto a table, comprise one of the larger groups of seized patents. These attack various problems. For example 1,819,221, 1,963,486 and 1,851,803 are concerned with the undulations or waves on the top surface which are expensive to grind out, and which are said to be due to the quicker cooling and contraction of the lower surface of the sheet in contact with the table. The first two of these patents tell of means for equalizing top and bottom cooling by rolling the upper surface with a grooved roller which leaves im-

pressions in the soft glass which increase the surface area, and hence the cooling rate. These impressions quickly disappear leaving a smooth surface. In the third patent Brancart deals with the even greater wave problem on sheets of abnormal thickness. The process suggests that the glass be ladled onto the surfaces of two rolls, there to form separate sheets which are merged into one thick sheet as these rolls come together.

Two other Brancart patents present what is said to be an improved means of regulating the height of the roll above the casting table which regulates the thickness of the rolled plate. These are 1,854,641 and 1,819,222, in both of which this adjustment is made by means of screws.

Since the outer edges of rolled sheets will tend to spread too thin due to the lack of confinement of the plastic glass, patent 1,851,804 proposes the use of convex roll which leave the glass thicker at the edge, to become even by its own free spreading action.

Others of the Brancart group propose means of breaking contact of the glass with the casting table so the glass will not cool too rapidly. In patent 1,819,670 a flat rod is kept moving to and fro under the sheet and air is blown through perforations in the rod. In 1,821,375 the table is perforated and contains under these perforations a combustible material such as charcoal which ignites from the heat of the glass to emit volatile gases which form an insulating film between the glass and the table. A similar principle is involved in 1,827,138 where Brancart slides a rolled sheet onto a receiving table over an inclined surface through which a moist gas is discharged to form a steam cushion to improve the polish.

Patent 1,819,224 is concerned with improved water cooling of a casting table surface, and 1,819,223 covers a train of rolls for receiving glass from a ladle and laying it down on a table. The rolling train is mounted on a rocking frame.

Brancarts patent 1,791,656 relates to the slab or sole plate made of refractory blocks which forms the hearth at the entrance to the annealing furnace. To avoid the opening of joints between these blocks by expansion and shrinkage he provides metal rods extending through them and kept tight by springs.

Pot Melted Plate Glass:

In 1,955,952, one of the patents assigned to S. A. des Mfg. des Glaces & Produits Chimiques de Saint-Gobain, A. D. H. Chan prescribes a course through which the pot may be moved in pouring glass onto a roll for plate glass manufacture. Chan's earlier patent 1,892,458 provides a retaining wall on top of a roll to hold the glass poured onto this roll before it is formed into a sheet by rolling through a pass between this roll and another. In patent 1,867,940 granted to Lucien Delloye of Paris the glass is poured into a trough instead of directly onto a roll, one side of the trough being a dam whose removal allows the glass to flow into the forming pass between two rolls.

Plate glass patents assigned to Compagnies Reunies des Glaces & Verres Speciaux du Nord de la France include three issued to Paul Despret of Paris. In 1,856,278 he melts the glass in pots and pours it into a small tank with less than twice the capacity of the pot, and flows a continuous sheet from a slotted wall. In 1,933,167 he describes perforated guide plates used on the sides of rolling machines to give the desired width to the glass, and in 2,010,916 he has revealed a process wherein glass is poured on a casting table in front of a roll and as the pour moves across the table an arm seizes the excess glass which would otherwise flow over the side plate, and throws it aside for return to the pot.

A machine for ladling and pouring molten glass is disclosed in 1,718,159 granted to Michel Laronde of Aniche, France.

Claude Locreille of Fauquez, Belgium, received patent 1,819,959 for a concrete casting table using smaller aggregate at the top surface, and 1,827,155 and 1,903,718 for printed glass. The latter is what he refers to as cathedral or hammered glass, and it is made by using a train of rolls, one having an embellished surface which impresses the sheet. The glass is poured on top of the rolls which lay it down on a table from which it is carried through an annealing furnace.

The Richard Genenger patents, (N. V. Maatschappij tot Beheer en Exploitatie Van Octrooien, The Hague), 1,869,245 and 1,833,248 describe respectively a device for handling and emptying pots, and a plate glass rolling machine. As shown by Fig. 6 the rolling train has a rocking base which allows it to tilt, pick up and empty the pot onto the rolls, and return the pot to its carriage while the glass sheet is being laid down onto a table.

Patent 1,930,424 to Paul J. M. Escole of Jeumont, France specifies apparatus for tilting a pot for pouring glass sheet, and 1,864,360 to J. H. Lemaire of Rousies, France, an apparatus which avoids the practice of pouring a large mass of glass on the first rolls; instead the glass is cast from pots into a hopper so that the glass will have roughly the shape of a sheet when it emerges for passage through the rolls.

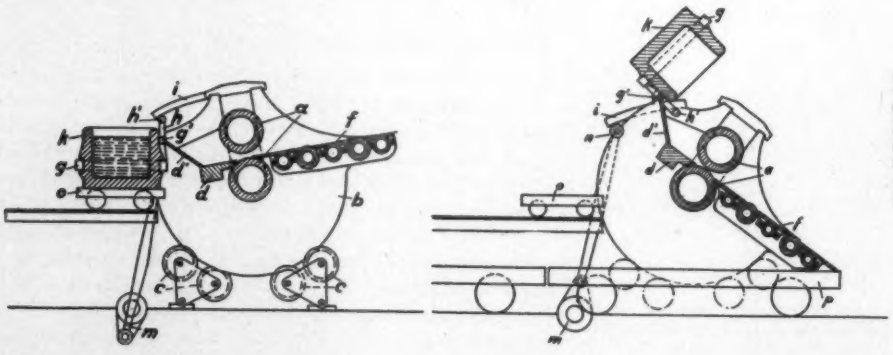

Fig. 6. 1,833,248: Geneger. Rocking train for pouring and rolling plate glass is shown at the left ready to pick up a pot, and at right while the sheet is being laid down.

Tempering Sheets, Etc.:

Seized patents on tempered glass granted to the well Bernard Long of Paris (S. A. des Mfg. des Glaces & Produits Chimiques de Saint-Gobain) include 1,960,222, 2,097,073 and 2,236,911. The first describes a process by which the cooling blast for tempering a heated sheet first impinges on certain areas and then is shifted to impinge on areas interposed between the first areas, and then returns to the first areas. The second patent covers the manufacture of mirrors from glass which is first tempered and then receives the metal application when cooled to 200-400 C. Metal is also applied to glass in the third of these patents but for another purpose: in tempering glass articles of unequal thickness the effect of more rapid cooling in the thinner sections will result in unequal temper, and at the weaker points Long applies a coating of metal.

Another group concerned with tempering sheets and plates are those assigned to Le Roi des Verres de Securite and consisting of patents 2,055,981 and 2,080,083 issued to Raymond Magnien and 2,078,541 to Robert Monnier, both of Paris. The first provides an induction furnace for heating the sheets prior to tempering, while the second concerns the arrangement of cooling jets shown in Fig. 7. Monnier's patent defines a pattern of movement to be taken by cooling jets in the tempering operation.

In connection with the difficulty of severing tempered sheets Edoardo Ferlito of Milan, Italy (2,293,537) proposed to groove a continuously drawn sheet from edge to edge while it was still soft, then to apply a cooling blast to the entire sheet and immediately afterwards to sever the sections at the grooves. Alberto Quentin also of Milan provides a frame in 2,297,246 for the support of sheets during tempering.

Patent 1,999,337 to Raymond Meer of Paris relates to the cooling of sheets to temper them and provides cooling jets from holes through tubes whose rotation changes the angle at which the jets strike the sheet.

Huu Chan in patent 2,262,545 placed a moving screen between the air blast source or heat supply and the ware to equalize the tempering treatment. This principle is applied also to other heating and cooling devices.

Bending Sheets:

Achille Verlay of Longueil, France (S. A. des Mfg. des Glaces & Produits Chemiques de Saint-Gobain) received patent 2,167,318 for means of heating and bending sheets suspended by a series of supports which engage the sheets at points near their upper edges, such supports being free to move laterally with the sheets and to turn on a vertical axis with the sheet while it is being bent.

Another patent to the same company is 2,250,628 issued to L. J-B. Forbes of St. Helene, England. The suspension supports which he provided for sheets while bending could also move into a curved plane when bending forces were applied. The supports are carried on rollers.

Laminated Sheets:

Omer Demaret of Belgium observed that cellophane sheds water when it has been treated with an alkaline bath, for example of 50 per cent caustic soda for 30 minutes, and proposed in 1,705,453 to use glass so coated and treated.

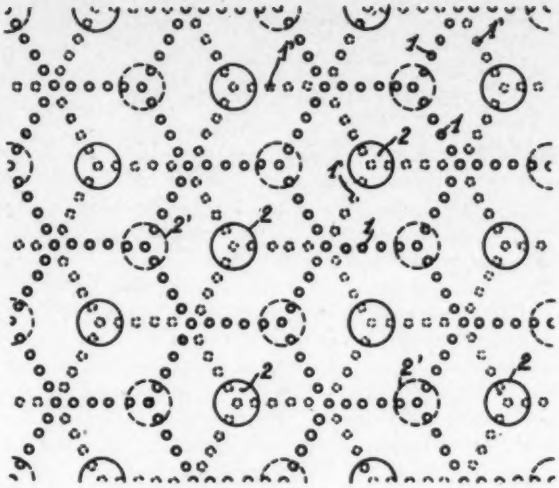

Fig. 7. 2,080,083: Magnien. In this pattern for cooling jets for use in tempering sheets, openings 1 are for blowing and 2 are for suction.

In autoclaving laminated safety glass for bonding, Robert Delloye of Paris reported in 1,934,682 that the cooling time could safely be reduced by spraying cold water into the autoclave while maintaining pressure by compressed air.

Jean Haas of Paris made laminated sheet in 2,020,178 by flowing the liquid plastic bond by pressure between the spaced sheets which it was to join.

The safety glass of 2,041,528 contains "an adhesive layer one of the constituents of which is an ester of silicic acid." The inventor was E. C. Cottet of Societe des Usines Chimiques Rhone-Poulenc, Paris.

The resin interlayer in patent 2,297,417 granted to Adolf Kampfer consists of a combination of two polymerized esters of vinyl acetate and acrylic acid.

Miscellaneous Sheet Processes:

Bernhard Engel's patent 2,305,683 for a method of producing sheet glass with a flashed coating of another color has the primary object of using a high shrinking flash which will apply permanent compressive stresses to the base sheet.

Patent 2,038,662 to Edmond Laverdisse of Auvelais, Belgium (Les Glaceries de la Sambre) offers an improved design for the supports which pick up sheets being transported from a rolling machine to the annealing furnace and which may crack them by thermal shock. Laverdisse tops them with a thin layer of a good heat conductor such as copper, underlain by a poor conductor.

A sheet annealing furnace of definitely proportioned cross-section is disclosed in 1,895,547 granted to Henry Lebel of Paris, and another lehr is described in 1,967,761 issued to L. von Reis of Herzogenrath, Germany. In this one the individual sheets pass a turntable at the lehr entrance so that they may be turned to enter the lehr in the direction of their widths.

Jules Arrault and Lucien Deschamps of Chalons-Sur-Saone, France, explain in patent 1,776,574 a means of flattening a window glass cylinder by means of tractive

(*Continued on page* 222)

BOOK REVIEW

"Prism and Lens Making"

By F. Twyman, F. Inst. P., F.R.S.

This little book is a real milestone in the life of the precision optics industry. For the first time a company of world wide repute gives us much detail of the processes involved in this delicate work. It seems to be so novel an idea that we have nothing to compare it with. The only other book that comes to mind is, "The Manufacture of Optical Glass and of Optical Systems," issued by the Ordnance Department at Washington. This was a record of production during the War of 1914-1918 and its subtitle is "A War-Time Problem," and is, therefore, a special problem, whereas, Mr. Twyman's book gives us the detail of production of precision optics as performed by a company whose product is recognized as the highest obtainable.

The first chapter on the history of the art is very good and of great interest, although we must say the ancients did not write much more concerning their processes than have the moderns.

Concerning some operations mentioned, one feels the methods are new and clever, while at other points, one feels that old and unsatisfactory methods are still used. It is very evident that the greatest advance has been made in the technique of processing the most exacting work and this is what could be expected coming from such masters as Adam Hilger, Ltd. Perhaps the best point in precision polishing is the device for controlling flatness on the single surface machine. This is so simple and yet so effective, anyone familiar with the trials of avoiding the usual concave center and the rounded-off edge will fully appreciate this device.

There are only two statements I would care to criticise in this book. One is in relation to the formation of scratches on glass surfaces during polishing. The other concerns the advisability of "drying up each wet." These two problems do not seem to be closely connected but in my opinion they are dependent on the viscosity of the surface of the pitch polisher. I venture to suggest that drafts and insufficient weight are the chief causes of scratches. A draft causes the exposed edge of the polisher surface to harden while the center of the polisher surface is covered by the work and kept warm. The warm center will sink in time leaving the hard edge to crumble and abrade the work. The amount of weight placed upon block should be sufficient to obtain a very slight but perceptible flow of the pitch into the grooves. If the weight be insufficient to cause this slight flow we can usually obtain good test but we have scratches. If the weight be too great we obtain poor test but scratch-free surfaces. Our problem is, like so many things in this life, that happy compromise between these two extremes. I am fully aware that all of the old artificers believe in "drying up each wet" but I consider that it is very desirable to have a constant viscosity of the surface of the pitch polisher to obtain best and quickest results. This will not be obtained by alternate wet and dry periods but by maintaining a constant moist condition.

The rather complicated method suggested of checking the flatness of flat tools can be avoided by the use of a so-called spider spherometer. This is an iron frame, holding three steel balls as in the Guild Spherometer, but these balls act as feet for the instrument and are on a circle of some nine inches diameter. A dial indicator reading to 1/500 mm. replaces the micrometer in the center. If we place this instrument on a good flat test plate and obtain a reading, and then place it on the flat tools, we compare the readings and with a spread of nine inches, the accuracy is in the neighborhood of seven Newton rings. The testing methods are excellent and do not think they could be improved upon at present.

The remarks concerning surface defects, or what are usually called "beauty defects" are very timely. Far too much time is now used in correcting and avoiding beauty defects that in no way affect the main function of the optical product. In normal times each producer has his own idea of customer acceptance of beauty defects, but in these times, utility and not beauty should be the aim, but I am afraid this is not always so.

This book puts before us for the first time, the details of the processes involved in producing precision optics; it is clear, lucid, and an important contribution to our exceedingly small library of test books. Its source is sufficient guarantee of its reliability. — *Adam Hilger, Ltd.* — $4.50.

R. S. Guilford

GLASSWARE INDUSTRY SIMPLIFIES LINES

Due to the increased demand for glassware by the Armed Forces the glass industry has had a heavy production load placed on its manufacturers of tumblers and tableware, which has resulted in a decrease of decorated novelties and a simplifying of individual lines of ware. In order to supply glassware for these essential uses the industry is sponsoring certain measures to provide as much volume as possible. One of their measures is a modified simplification program, the variety of styles, shapes, and sizes of tableware and tumblers available. New items that might require restricted metal for new molds will be dispensed with for the duration, and less popular or marginal items are being discontinued. This should result in an increase in ware produced, as no time is lost in switching molds or changing operations.

OWENS-CORNING LEASES PLANT FOR WAR PRODUCTION

Owens-Corning Fiberglas Corporation has leased a factory in Pennsylvania from the Defense Plant Corporation, an RFC subsidiary, in order to produce more glass fiber yarns to be used for war materials. The glass textiles are furnished for end uses approved by the War Production Board under Conservation Order M-282 which lists glass fiber textiles as critical material.

The new addition to the Owens-Corning Company has the endorsement of the Army Air Forces who have informed Owens-Corning that this sponsorship was granted because of a conviction that glass fiber textiles, in combination with other materials, possess properties of outstanding military importance for use in plane construction, as well as for insulation of air-borne electrical equipment.

BERYLLIUM IN GLASS

By KUAN-HAN SUN
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PART II

Borate Glasses

The solubility of BeO in B_2O_3 was studied by Foex[18], who stated that at 1200°C. 100 moles B_2O_3 dissolve about 0.53 mole BeO. Menzel and Sliwinsky[53], however, made some BeO-B_2O_3 glasses with the BeO content as high as 15 weight per cent or 33 mole per cent. Tillyer, Moulton, and Gunn[78] showed that the addition of BeO to ZnO-B_2O_3 glasses increases their strength as one would expect from the great strength of the Be-O bond. By far the most important Be-borate glasses are those in the BeO-Li_2O-B_2O_3 system. These include the well-known Lindemann glasses. The study of glasses in this system has been primarily for the purpose of obtaining satisfactory glass windows for x-ray tubes. The transmission of x-rays through a sheet of material such as a glass window obeys the relation

$$I/I_0 = e^{-\mu t}, \qquad (1)$$

where I/I_0 is the fraction of x-rays transmitted, t is the thickness of the sheet, and μ is the linear absorption coefficient. This coefficient may be calculated additively from composition by the following equation

$$\mu = d\Sigma\frac{\mu}{\rho}f, \qquad (2)$$

where d is the density of the material, f is the weight fraction of a given element in it, and $\frac{\mu}{\rho}$ is the mass absorption coefficient for that element, a function which increases continuously with atomic number for a given x-ray wave length (provided all these elements have relatively low atomic numbers). It is obvious from these two equations that the higher the atomic numbers of the constituent atoms, the higher will be the $\frac{\mu}{\rho}$ values and the lower the transmission. For a material to be suitable for use in windows of x-ray tubes, transmission is required. Naturally, the light elements (such as Li, Be, B, and O, those present in the system BeO-Li_2O-B_2O_3) are the most desirable constituents of the glass. Although metallic beryllium or hydrocarbon plastics may have higher transmission than these low atomic number glasses, the latter have the advantage of being fusible to the glass body of the x-ray tube.

Glasses in the system BeO-Li_2O-B_2O_3 are called "Lindemann glasses," after Lindemann and Lindemann[46], who were the first to make them. Their patented glass has the weight composition: 83.5% $Li_2B_4O_7$, 14% B_2O_3, and 2.5% BeO. (This glass is also included in Table II, where its composition is given in terms of the component oxides.) Botvinkin[7], Wellmann[83, 84], Ziegler and Wellmann[91], Schleede and Wellmann[67], Hertsriken and Revutskaya[32], Hertsriken[31], Mazelev[52], and Menzel and Sliwinski[53] have also made practical glasses in this system. The compositions are given in Table II and III and represented graphically in Figure 1. It is interesting to note that the weight percentages of B_2O_3 in all of the practical glasses are over 80 per cent. Wellmann has suggested the replacement of Li_2O by other alkali oxides.

These glasses have high transmission not only for x-rays but also for ultraviolet rays, according to Ziegler and Wellmann. The glass studied by them transmits the wave lengths down to 1900 A, whereas the limit of transmission of vitreous SiO_2 is 2200 A. This glass is stable, can be fused to other glasses, and becomes fluid at about 750°C. They suggested its use in the mercury-vapor lamp.

Rudenko and Hertsriken[65] measured the absorption coefficients of glasses in this system in the infrared region 8000-25000 A. "The absorption begins to be considerable at 16000 A. The absorption coefficient increases sharply beyond this wave length and is much greater than that for ordinary silicate glasses. The value of the absorption coefficient varies greatly with the chemical composition of the glass and increases for all wave lengths with increase in the ratio $Li_2B_4O_7$:BeB_4O_7." In other words, Li_2O increases the absorption coefficient much faster than does BeO.

The specific heat of the Lindemann and Lindemann glass in the temperature range —238.8 to —158.30°C. was measured by Simon[69]; the results are summarized by Morey in his monograph. The shape of the specific heat-temperature curve for the Lindemann glass is similar to that for vitreous SiO_2.

The most comprehensive studies in this system are those of Mazelev[52], and of Menzel and Sliwinski[53].

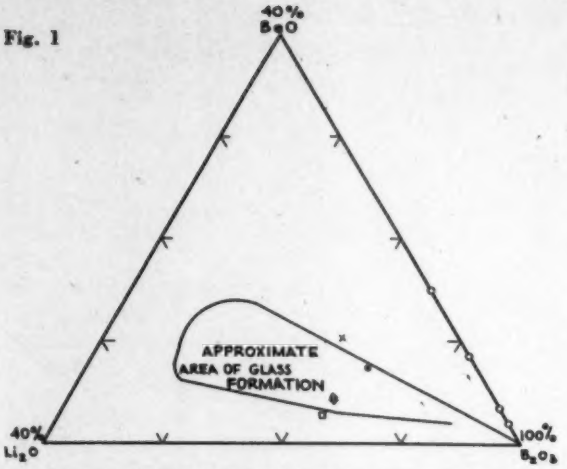
TABLE II

Compositions of Practical Glass in System BeO-Li_2O-B_2O_3

	Compositions Weight Per Cent BeO	Li_2O	B_2O_3	Remarks
Lindemann and Lindemann	2.5	15.7	81.8	
Botvinkin	10	10	80	Density 2.20
Wellmann	4.0	13.7	82.3	Tough, stable, low melting and high ultraviolet transmission.
Ziegler and Wellmann	4.4	13.6	82	
Hertsriken and Revutskaya	7.5	9.0	83.5	
Mazelev	See Table III			
Menzel and Sliwinski	See Table III			

They studied the composition range within which transparent glasses could be obtained. This is shown in Figure 1. Mazelev measured the specific gravity, refractive index, coefficient of thermal expansion, softening point, and solubility in water of 25 glasses. For a given molecular ratio of BeO to B_2O_3, the addition of Li_2O increases the density, refractive index, coefficient of thermal expansion, and (slightly) the water-solubility of the glass. For a given ratio of Li_2O to B_2O_3, the addition of BeO increases the density, refractive index, and coefficient of thermal expansion, but decreases the water-solubility. For a given ratio of Li_2O to BeO, the addi-

Fig. 1



□ LINDEMANN AND LINDEMANN • GERTSRIKEN AND REVUTSKAYA
▲ ZIEGLER AND WELLMANN × BOTVINKIN
▼ WELLMANN ○ MENZEL AND SLIWINSKI
THE APPROXIMATE AREA OF GLASS FORMATION IS OBTAINED FROM DATA BY MAZELEV AND BY MENZEL AND SLIWINSKI. THE EXACT BOUNDARIES ARE NOT TOO CERTAIN

tion of B_2O_3 decreases the density, refractive index, and coefficient of thermal expansion, and slightly increases the water-solubility. Menzel and Sliwinski measured the density, refractive index, chemical resistance, and transmission of W and CuKα x-rays for 13 glasses. Their data, as published, are not suitable for the establishment, without detailed analysis, of useful generalizations concerning property-composition relationships.

Owing to the fact that Mazelev's paper is in Russian and neither available nor readily understandable to most readers, the compositions and properties of his glasses are reproduced in Table III. Menzel and Sliwinski's data are also listed because of the scarcity of the current German journals. (Both of these articles are, however, available on microfilm. The Russian article may be obtained from the Bibliofilm Service, Washington, D. C.; the other, from the Microfilm, Inc., Ann Arbor, Michigan.)

PHOSPHATE GLASSES

General reviews dealing with phosphate glasses have been published recently by Knapp[42] and Kreidl and Weyl[43]. These glasses were neglected for many years, largely because of the instability of early products. Lately, however, it has been shown[27, 28, 41, 43] that stable phosphate glasses can be produced, provided they contain alumina in suitable amounts. The stability of such glasses is no doubt due to the presence of a network of PO_4 and AlO_4 tetrahedra. We have pointed out in the early part of discussion that BeO is an intermediate oxide, behaving like Al_2O_3. One should therefore expect that beryllium phosphate glass will also be stable. Such glasses have been made by Chem. Fabrik J. A. Benckiser Co. and F. Draisbach[11], Tillyer, Moulton, and Gunn[79, 80], Young[74], and the writer[76]. All these beryllium phosphate glasses are colorless and stable. They are also transparent to ultraviolet light, as observed by Draisbach[11]. The limit of transparency is 2140 A. for a beryllium metaphosphate glass. Nussbaum and Zambra[58] introduced BeO into some complex phosphate glasses.

GERMANATE GLASSES

Among all the glass-formers, SiO_2, B_2O_3, P_2O_5, and GeO_2 are probably the most important. The oxides of arsenic and antimony would be included in this list, if they were not so volatile. The study of beryllium germanate glasses would be of interest. No such glass has been reported in the literature, though Goldschmidt[24] has mentioned that the compound Be_2GeO_4 melts incongruently, indicating that a glass of this composition is difficult or impossible to make.

FLUORIDE GLASSES

Pure Fluoride Glasses

As already mentioned, BeF_2 is the only known glass-former among the fluorides. It is colorless, transparent, and hygroscopic. It becomes mobile at 800°C. Biltz and Rahlfs[6] determined the density of the glass at 25°C. as 1.986 gm./cc. No refractive index value has been given in the literature. Safford[66], however, stated that it is lower than that of methyl alcohol (1.3).

In the case of oxide glasses, it is well known that a glass may be formed by compounding a non-glass forming oxides, such as Na_2O, K_2O, etc., with a glass-forming oxide, such as SiO_2 or B_2O_3, provided the ratio of the total number of oxygen atoms to the total number of atoms of glass-forming elements (e.g., Si) is considerably less than 4.* By analogy, one would expect to get glasses by compounding non-glass forming fluorides with BeF_2. Goldschmidt[23] was the first to make such glasses, obtaining some in the LiF-BeF_2 system. The only subsequent comprehensive study of fluoride glasses was made by Heyne[33], who made several glasses in each of the systems: MF-BeF_2, MF-MgF_2-BeF_2, MF-CaF_2-BeF_2, MF-AlF_3-BeF_2. MF represents LiF, NaF, KF, or a combination of NaF and KF. Other glasses have been made by incorporating $NaPO_3$ into each of the above systems except MF-MgF_2-BeF_2. As a matter of fact, $NaPO_3$ melts with MF-BeF_2 glasses in almost all proportions. BeO dissolves in NaF-BeF_2 glasses to an extent of about 1 per cent. Alkali sulfates can be added to KF-BeF_2 glasses up to about 20 per cent. Small amounts of CoF_2 may be added to KF-BeF_2 glasses to give a violet color. Only very small amount of zinc, zirconium, and titanium fluorides can be added to the alkali beryllium fluoride glasses. In general, excess BeF_2 causes opacity and excess of other metallic fluorides causes devitrification.

A potassium aluminum fluoride glass has a density of 2.35 g/cc. and hardness of 4 on the Mohs scale. These values are to be compared with average density and hardness values of about 2.5 and 6, respectively, for common silicate glasses.

The coefficients of thermal expansion, within the temperature range 20-100°C., of six fluoride glasses have been measured and collected in Morey's book. They are about (200-300) x 10^{-7} as compared to (10-100) x 10^{-7} for various kinds of industrial glasses. Heyne's method of measuring the "softening point" was empirical in nature. His results indicate, however, that the "softening points" of these glasses are very low, about 150 to 300°C. The addition of MgF_2, CaF_2, and AlF_3 usually

*Zachariasen[80] stated that for most stable silicate glasses, the O:Si ratio is in the neighborhood of 2.5, though glasses with the O:Si ratio greater than 4 have been obtained.

lowers the expansion and increases the stability, and thus improves the properties. The transmission of the fluoride glasses in the infrared is only a little better than that of ordinary silicate glasses. But in the ultraviolet region, the fluoride glasses are much superior. Some transmit down to about 2200 A.

Thomaschek and Deutschbein[77] measured the fluorescence spectrum of a BeF_2 glass containing 1 per cent EuF_3.

To summarize, one may say that fluoride glasses are interesting theoretically but not commercially, because of their lack of stability toward weathering.

Fluoride-Oxide Glasses

More desirable properties are possessed by some fluoride-oxide glasses—glasses having as components both fluorides and oxides. Oxide and fluoride ions are of about the same size and are interchangeable in many minerals just as Na or Al are interchangeable with Ca, as illustrated by Bragg[8]. For such interchange, it is usually the size rather than the valence which is important (provided the sum of the ionic charges is kept equal to zero). The replacement of oxygen by fluorine was discussed by Weyl[85]. As he pointed out, this substitution weakens the glass structure, because of lower valence of fluorine. Homogeneous and transparent fluorine-containing glasses* have been produced and are important to optical designers. Although there has been no systematic study, the addition of fluoride to oxide glasses is usually considered to have the effect of increasing the dispersion at the blue end of the spectrum and of decreasing it at the red end. It also decreases the dis-

TABLE III

Compositions and Properties of BeO-Li_2O-B_2O_3 Glasses

Data by Mazelev*

Original Glass No.	Compositions	Weight	Per Cent	Specific Gravity	Refractive Index	Solubility** in Water Per Cent	Coef. of Linear Expansion x 10^6 (20—320°C.)	Softening Point °C.
	BeO	Li_2O	B_2O_3					
13	14.34	16.35	68.87	2.2754	1.562	40.7	891	500
14	14.62	15.50	69.88	2.2719	1.558	36.3	....	...
15	14.08	17.56	68.36	2.2793	1.564	43.04	934	485
20	11.14	13.91	74.95	2.1892	1.552	60.90	742	495
21	11.07	16.51	72.42	2.2429	1.558	53.8	812	498
22	11.95	17.82	70.23	2.2599	1.564	48.5	896	490
26	8.82	10.52	80.65	2.0998	1.542	75.1	718	495
27	8.41	13.33	78.27	2.1596	1.550	76.28	720	500
28	8.42	15.17	76.41	2.1973	1.550	77.4	758	500
29	8.74	17.81	73.45	2.2564	1.562	80.7	800	480
30	8.91	18.53	72.56	2.2546	1.564	80.1	833	475
33	5.96	7.97	86.07	2.0677	1.530	80.3	625	498
34	5.93	10.57	83.50	2.0870	1.538	86.81	675	500
35	6.01	13.03	80.96	2.1159	1.548	88.90	713	492
36	5.20	13.74	81.06	2.1077	1.549	91.30	715	480
37	5.90	15.29	78.81	2.1478	1.552	88.6	735	498
38	5.83	17.78	76.39	2.2092	1.560	88.6	769	479
39	6.08	20.18	73.74	2.2212	1.566	89.8	886	478
40	5.74	22.62	71.64	2.2743	1.570	89.9	940	460
41	5.95	24.27	69.78	2.2850	1.574	90.25	1017	440
42	3.88	6.11	89.74	2.0043	1.520	88.6	....	...
43	3.12	10.39	86.49	2.0766	1.535	91.8	631	488
44	3.06	14.38	82.56	2.0943	1.547	92.9	690	504
45	3.14	14.74	82.12	2.1073	1.549	92.6	667	482
46	3.03	15.31	81.66	2.1132	1.550	93.6	695	490
GETAN—1	13.00	15.00	72.00	2.22	1.556	48	....	770
GETAN—2	8.50	20.30	71.20	2.26	1.566	72	....	890
GETAN—4	5.10	24.40	70.50	.....	....	....	....	...

Data by Menzel and Sliwinski

Original Glass No.	Compositions	Weight	Per Cent	Density gm./cc.	Refractive Index	Chemical Durability Percentage Change After 30 days	Chemical Durability Percentage Change After 100 days	X-Ray Transmission Per Cent W radiation	X-Ray Transmission Per Cent CuK α radiation
	BeO	Li_2O	B_2O_3						
3	9.89	15.33	74.78	2.2345	1.5523	0.08	0.11	81	71
4	10.21	21.04	68.75	2.2537	1.5593	0.17	0.26	85	69
6	6.56	16.25	77.19	2.2526	1.5933	0.14	0.17	80	72
11	2.01	8.27	89.72	2.0967	1.5147	18.99	35.5	79	..
14	1.96	5.39	92.65	2.0138	1.4980	54.7	56.4	83	..
17	5.60	22.69	71.71	2.2540(!)	1.5605	0.26	0.34	81	71
18	7.78	12.29	79.93	2.2015	1.5380	0.37	0.61	82	71
19	7.10	9.39	83.51	2.1642	1.5300	4.99	9.05	77	..
20	4.85	10.34	84.81	2.1509	1.5300	1.10	1.13	80	..
21	8.21	19.11	72.69	2.2512	1.5574	0.31	0.45	81	71
28	5.40	20.25	74.35	2.2709	1.5579	0.17	0.21	84	71
29	8.44	23.73	67.83	2.2607	1.5608	0.22	0.33	80	73
30	11.01	18.84	70.16	2.2600	1.5566	0.10	0.14	82	71

*Thanks are due Miss Elsie Garvin and Mr. W. Eichler for their help in the translation of this Russian article.
**The decimal place in all the values in this column may have been misprinted in the original article.

persion throughout the visible region. Lithium fluoride, despite its instability, has been used in optics because of its low dispersion and high Abbe value (99.31)[47].

The literature contains only fragmentary data on the introduction of fluorides into oxide glasses. The well-known fluo-crown glass contains up to about 10 per cent of fluorine (see, for example, Morey[56], pages 411 and 419). Zschimmer[92] discussed the introduction of fluorine in optical glass. Heyne[33] stated that alkali metal-beryllium fluoride glasses can be melted in any proportion with sodium metaphosphate. Amstutz and Borloz[2] studied the solubility of SiO_2, Al_2O_3, and BeO in BeF_2. Lindemann and Lindemann[46] mentioned that fluorides of low atomic weight-elements may be introduced into the lithium beryllium borate glass. Locke and Locke[48, 49] introduced about 17 per cent CaF_2 into a borosilicate batch, and reported that large amounts of CaF_2 can be introduced into glasses of high alumina content. Kreidl and Weyl[43] introduced 20 weight per cent CaF_2 into an aluminum phosphate glass. Recently glasses in the binary systems MgF_2-SiO_2, CaF_2-SiO_2 have been studied by Choong [12, 13], and LiF-B_2O_3 glasses by Baumgarten[4].

These studies indicate that fluorides can be introduced in rather large quantities into silicate, borate, and phosphate glasses. They open up a new and interesting field, from both theoretical and practical points of view. A study of the role of beryllium in these glasses should prove of especial interest, because it is an element which contributes desirable properties to oxide glasses and also forms strong bonds to fluorine in fluoride glasses.

CALCULATION OF PROPERTIES OF A BERYLLIUM-CONTAINING GLASS FROM ITS COMPOSITION

The calculation of the properties of a glass from its composition has received considerable attention in recent years. For beryllium-containing glasses, it is possible to calculate from their compositions, values of density, linear coefficient of thermal expansion, refraction, refractive index, dispersion, Abbe value, partial dispersion ratios and mass absorption coefficient for x-rays.

Density, Refraction, Refractive Index, Dispersion, Abbe Value, and Partial Dispersion Ratios

The correlation of these properties of glasses with their compositions has been comprehensively reviewed by Sun, Safford, and Silverman[70-71]. Soon after the publication of this review, there appeared a series of papers by Huggins[35, 36, 37, 38], dealing with the calculation of these properties from composition, also a paper on refraction and dispersion by Young and Finn[89]. More recently, Huggins, Sun, and Davis[40] have extended Huggins' treatment and Huggins and Sun[39] have presented a summary of methods of calculation of these properties from composition expressed in weight percentages. BeO has been included as one of many components treated. A discussion of such calculations here would be unnecessary repetition.

Coefficient of Thermal Expansion

There has been no comprehensive study of the calculation of thermal expansion coefficients from composition. The empirical additive formula suggested by Winkelmann and Schott[88] is fundamentally incorrect, as pointed out by Sun and Silverman[72, 73]. Nevertheless, it is the only convenient formula now available for practical use. Using this formula, Rencker[64] derived the following relation for the calculation of the linear coefficient or thermal expansion, α, of a glass in the system BeO-Na_2O-SiO_2:

$$\alpha \times 10^8 = 2p_{SiO_2} + 2p_{BeO} + 37p_{Na_2O} \qquad (3)$$

Here, p_{SiO_2}, p_{BeO}, and p_{Na_2O} are the weight percentages of SiO_2, BeO, and Na_2O, respectively. It is obvious that this equation does not apply to pure vitreous SiO_2 or to high SiO_2-containing glasses, as the coefficient of expansion for vitreous SiO_2 is about 5×10^{-7}. The equation is empirical in nature and applies only to a single system—and to that only within limited ranges of composition. Other formulas proposed by Mayer and Havas[51] and by Gilard and Dubrul[20] are subject to the same criticism, except that Gilard and Dubrul's equation and constants may be applied to glasses other than those in the BeO-Na_2O-SiO_2 system.

Linear Absorption Coefficient for X-Rays

As shown in equation (2), the linear absorption coefficient of a glass can be calculated from its composition. The mass absorption coefficient $\frac{\mu}{\rho}$, for various elements at various wave lengths are given elsewhere (e.g., Bragg[9], pages 325-327). Gotteried[25] used these factors to calculate the linear absorption coefficients of several beryllium sodium silicate glasses and obtained good agreement with experimental values.

*The so-called fluor crown glasses. Their compositions, however, have never been divulged in the literature.

The writer is deeply indebted to Dr. Maurice L. Huggins of the Kodak Research Laboratories for many theoretical discussions and for his kind help in the preparation of this paper.

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(*Continued on page 222*)

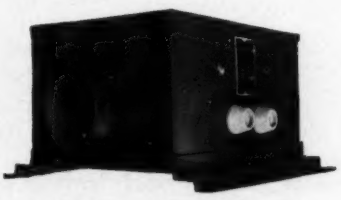
NEW EQUIPMENT AND SUPPLIES

NEW CLEANSING AGENT FOR GLASS

Alconol, a new detergent, has just been put on the market by Standard Scientific Supply Corporation, New York City. This cleansing agent comes in dry form and is said to produce an abundant, highly efficient lather in water of any degree of hardness without the formation of insoluble calcium soap. So far it has been found to be an excellent cleanser of glass, porcelain and metal, and unlike soaps or strong alkalis the surface tension depressant of Alconol is so great that no film is left on the glass.

GE ELECTRONIC METER

The Special Products section of the General Electric Company has announced a new electronic time-interval meter for accurately measuring extremely short intervals. This meter is specifically designed for measuring the time interval between two events which can be converted into electrical impulses, such as the elapsed time between the closing of two controls, between two impulses to a phototube; and between an electrical impulse and a light impulse.



COLD CATHODE TRANSFORMER

Especially designed for industrial applications is a new style Cold Cathode Lighting transformer with a capacity of 120 miliamperes in 3000, 4000, 6000, 9,000, 12000, or 15000 volt secondaries, announced by the Acme Electric and Manufacturing Company. Cold Cathode lighting which uses a minimum of critical materials has been successfully tested in many war production plants throughout the country.

Similar in basic manufacturing process to the luminous tubes used in "Neon Signs," Cold Cathode tubes of 20 to 25 mm. diameter can be used in multiple parallel strips, and curved to follow the contour of a building or production line. The brilliant bright light can be color-mixed to make inspection work stand out in relief.

ADDITION TO TABER ABRASER

An attachment for the Taber Abraser called the Shear-Hardness Attachment has been recently released by the Taber Instrument Corporation. This attachment provides an accurate method to measure the toughness quality of surface finishes and their ability to resist digs, scrapes and similar abuse from actual service not considered normal wear.

In addition, the Taber Abraser efficiently and accurately evaluates resistance of surface finishes action by rubbing abrasion. Scientific wearing action by "Calibrase" wheels on specimen clamped to revolving turn-table is measured in terms of "wear cycles" which are automatically totalled on built-in counter. Only a 4" square sample is required to make the easy, quick test.

WORKERS' GOGGLES CLEANED

To keep the goggles of workers clean the Mine Safety Appliance Company of Pittsburgh has released a convenient wall mounting for plants which is equipped with Fogpruf, a lens cleaning and anti-fogging agent, and Optical Wiping Tissues. A tap on the inverted vial sprays Fogpruf on the goggle or spectacle lens. Cleaning tissues are then pulled from the opening in the top of the Station and may be discarded in a receptacle in the lower part of the case.

CATALOGS RECEIVED

Reeves Pulley Company, Columbus, Indiana. Catalogue No. TR-432, just released by the Reeves Pulley Company, covers their new unit, the Reeves Reducer-Type Transmission. It contains a description of the unit as well as engineering data and rating tables.

Surface Combustion, Toledo, Ohio. "Heat for War and Post-War in the Glass Industry." A colorful and artistic booklet has been released by the Surface Combustion Company dealing with the future of glass, and Surface Combustion's role in resarch for the present heat treatment of glass and for the future.

Eisler Engineering Co., Inc., Newark, New Jersey. A new 94 page catalog has just been completed by the Eisler Company which is one of the most complete of its kind for glass working and glass laboratory schools and colleges. The catalog describes all types of gas, air and oxygen burners, economizers, gas and air mixers and glass rollers and includes over 750 illustrations.

Chicago Eye Shield Company, Chicago, Illinois. Industrial safety equipment providing protection for the head, eyes, nose, throat, lungs and other parts of the body is described in the 25th edition of this catalog.

Coast Metals, Inc., Canton, Ohio. A process called Hard-Facing which restores worn parts of machinery to their original dimensions by means of a welded overlay of a hard alloy is described in a recent bulletin put out by the Coast Metals Company. It can be used to advantage on equipment that is exposed to wear, abrasion, impact and heat.

Laclede-Christy Clay Products Co., St. Louis, Missouri. A new pamphlet is available on Laclede Setskold for laying and surfacing fire brick. It gives instructions for its use and the advantages of its application.

Leeds & Northrup Company, Philadelphia, Pennsylvania. The new edition of a catalog on Micromax Pneumatic Control has been published by Leeds & Northrup, stressing the use of this equipment for regulation of pH, conductivity and other conditions.

E. I. du Pont de Nemours & Company, Wilmington, Delaware. A new bulletin "Polyvinyl Acetate; Solid, Solution & Emulsion Forms," has been issued by the Electrochemicals Department, describing this thermoplastic resin which adheres firmly to glass, ceramics, metals, wood, leather, paper and other surfaces. The bulletin gives the properties, applications and other information about the plastic.

CATALOG & BULLETIN SERVICE

Current catalogs and manufacturers' service bulletins reviewed in this department may be obtained by writing to THE GLASS INDUSTRY.

BERYLLIUM . . .

(*Continued from page* 220)

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FOREIGN PATENTS . . .

(*Continued from page* 215)

forces exerted by an assembly of bars with an extensible connection between them, which spread the cylinder out.

Miscellaneous Patents:

Norbert Kreidl of Reitendorf-on-the-Tess, Czechoslovakia, was the inventor of patents 1,899,760, 1,975,397, and 1,947,781 for colored glass. The first two are opalescent glasses made of a number of layers. In the first patent at least one layer is a fluorescent light-transmitting glass while another is a different intensely colored glass. In this patent and 1,975,397 one layer is at least partially transparent to light rays transmitted by the other layer. In addition the latter patent provides one of the layers with a geometrically configured surface for light refraction. In the third patent Kreidl finds that the two step process of obtaining a copper red flashing by first burning the coating onto a glass article, and then reburning with reducing agents such as charcoal, can be reduced to one step by applying the coating to a glass containing sulphides.

Claude Locreille of Fauquez, Belgium produced marbled and multi-colored glass in patent 1,832,491 by preparing masses of glass of similar composition, but of different colors, and pouring separate quantities of fairly stiff glass into a highly fluid mass of one of the glasses.

In patent 1,796,571 Louis Mathieu of Paris made spun glass by drawing through a perforated plate in the side wall of the furnace.

Bernard Long's patent 1,668,853 concerns a process of uniting vitreous surfaces by accurately fitting the surfaces to be joined, smoothing as with fine emery, applying to this surface a film of heated synthetic resin, and uniting the surfaces under pressure and heat.

Methods of assembling the heads of incandescent lamps are disclosed in patent 1,606,276 issued to L. S. Vello of Paris.

A chuck for holding glass articles of many shapes for rotation and working is described in 1,797,836 granted to Edmond Paul of Soignes, Belgium.

Patent 1,987,734 issued to P. H. de Fonbrune of Boulogne-sur-Seine, describes a method and apparatus for drawing fine glass needles for biological experiments.

RESTRICTIONS EASED ON ZINC OXIDE

Although formerly on allocation, as a result of a recent change in General Preference Order M-11 the availability of zinc oxide has been greatly improved. The change in the order relieves the consumer of furnishing a written statement to suppliers that receipt of a shipment of zinc oxide would not increase his inventory in excess of a necessary minimum working stock. American Process zinc oxide is now available without priority ratings to glass manufacturers.

RECLAIMED FUEL OIL EXEMPT FROM RATIONING

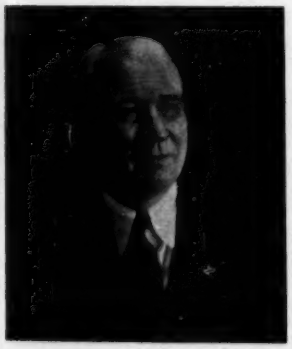
Used and re-refined lubricating oil which can be used as a substitute for the heavy types of fuel oil in industrial heating and processing has been exempted from the fuel oil rationing regulations by the Office of Price Administration. This reclaimed lubricating oil can be burned in place of No. 5 and Bunker "C" fuel oil in furnaces designed to use these heavy fuel oils, after it has been filtered and heated to remove foreign particles and gasoline.

TWO DIRECTORS ADDED TO OVERMYER MOULD CO. BOARD

Two more Directors were added to the Board of the Overmyer Mould Company of Winchester, Indiana, at a recent stockholders meeting, and were elected for the year 1943. The Board will now consist of seven directors instead of five as heretofore. This was considered necessary because of the greatly expanded business of the company, due to the large production of war materials at the present time. The following were elected to the Board: D. S. Haines, Morton Longnecker, Cedric Briner, C. P. Overmyer, Jr., E. E. Sandifar, Lowell Roesner and C. P. Overmyer. Officers chosen were C. P. Overmyer, Sr., President; D. S. Haines, 1st Vice-President; C. P. Overmyer, Jr., Second Vice-President; Cedric Briner, 3rd Vice-President; E. E. Sandifar, Secretary, and Morton Longnecker, Treasurer.

DR. LANDIS RECEIVES GOLD MEDAL

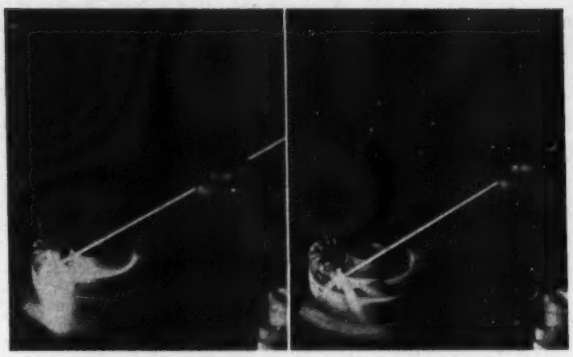
Dr. Walter Savage Landis, vice president of the American Cyanamid Company, will be presented with the Gold Medal of the American Institute of Chemists at the annual meeting of the Institute in May. This medal is awarded annually for outstanding services to the science of chemistry, and is being presented to Dr. Landis in recognition of his contributions to chemical engineering and development work, largely in the field of nitrogen derivatives and for his services to the professional side of chemistry.



Dr. Landis developed a method for the fixation of atmospheric nitrogen by producing ammonia from cyanamid and oxidizing it to nitric acid, and also processes for the production of hydrocyanic acid, cyanides, ferrocyanides, dicyandiamid, and ureau from cyanamid.

A graduate of Lehigh University with the degrees of metallurgical engineer, M.S. and an honorary Sc.D., Dr. Landis studied for some time at Heidelberg, Germany and Aachen. He joined the American Cyanamid Company in 1912 and has been actively associated with the company ever since.

Many patents have been granted to Dr. Landis and he is the author of numerous articles. He is a member of many chemical societies and institutes and has been presented with the Chemical Industry Medal and the Perkins Medal.



Picture 1—Photograph taken through an ordinary welding lens—the "sodium flare" obscures the rod and bead.
Picture 2—Photograph taken through the new Noviweld-Didymium lens—note how the "sodium flare" has been screened out, revealing the entire working area in sharp relief.

Note: Unretouched photographs taken and developed under identical conditions.

NEW GLASS INCREASES WELDER'S VISION

Production of welded battle equipment for the Army and Navy is expected to increase due to a new eye-protection glass recently announced by Dr. E. D. Tillyer, research director of the American Optical Company. This new glass permits the eyes of gas welders to pierce blinding glare and see welding operations from beginning to end.

Previously, Dr. Tillyer stated, the glare of flame-welding made it impossible for welders to see exactly what they were doing—a factor slowing the welding of planes, tanks, ships, and other military equipment. Lenses made from the glass, he said, now let a welder look through the cloudy yellow flames of burning sodium vapors and see clearly the welding rod and the molten area.

The new glass was developed by adding didynium, a rare metal, to the composition of a standard welding glass, the result being a distinctively new glass with exceptional ray-absorbing properties in the visible and invisible portions of the spectrum.

LIBBEY-OWENS-FORD ACQUIRES PLASKON COMPANY

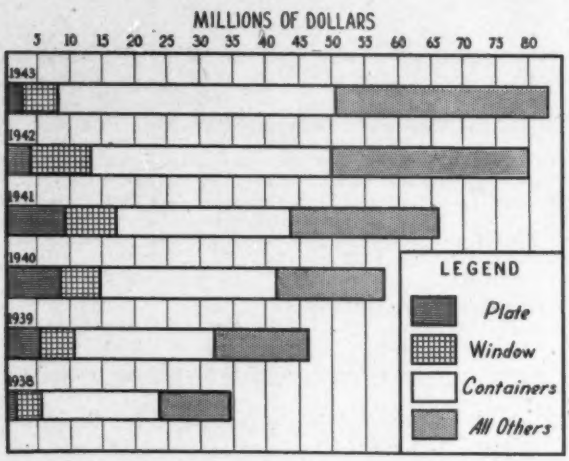
Shareholders of Plaskon Company, Inc., the nation's largest manufacturer of urea plastic molding compounds and adhesives, voted to approve the exchange of the company's remaining outstanding stock for shares of the Libbey-Owens-Ford Glass Company on April 15, thus becoming a division of the glass company.

Directors of the glass company also elected James L. Rodgers, Jr., who has been president of Plaskon since 1927, a vice-president of Libbey-Owens-Ford, in charge of the Plaskon Division, and elected L. G. Bryan vice-president in charge of production for L-O-F. Frank Fraser, manager of the L-O-F patent department, and C. O. Marshall, secretary of Plaskon, were elected assistant secretaries of Libbey-Owens-Ford.

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX

Production: Two Months, January Through February



During February, production in the glass industry amounted to $40,000,000, a slight decrease from the January total but an increase of 13 per cent over last year's figure. Employment and payrolls remained at about the same levels. During the first two months of this year production was estimated at $83,000,000 — 3 per cent ahead of last year.

Plate glass production during March totalled 5,236,777 square feet. This represented a decrease of 5 per cent from March of last year but an increase of 9 per cent over February 1943. During the first quarter of 1943 plate glass output amounted to 14,921,921 square feet or 26 per cent less than last year.

Window glass production during March increased 12 per cent over the February figure to 1,248,536 boxes but 21 per cent less than last year's comparable total. During the first quarter of 1943 window glass output totalled 3,527,494 boxes, a decrease of 25 per cent from last year's first quarter production. During March the window glass industry operated at 76.9 per cent of capacity.

Glass container production during March totalled 7,561,374 gross according to the Glass Container Association of America. This was 13 per cent above the February volume and 10 per cent greater than the March 1942 total. During the first quarter of 1943 glass container production totalled 21,593,899 gross, which was 10 per cent above the 1942 level.

Shipments of glass containers during March amounted to 8,154,457 gross. This was 15 per cent more than the March 1942 volume. Increases were reported over last year for domestic fruit jars of 239 per cent; wide mouth food bottles and jars, 41 per cent; general purpose ware, 28 per cent; and beer bottles, 28 per cent. Greatest decreases were seen in domestic jelly glasses, 30 per cent, and narrow neck food containers, 16 per cent. Total shipments for the first quarter of 1943 amounted to 22,459,892 gross, an increase of 17 per cent over last year, with domestic fruit jars and beer bottles showing the largest gains.

Stocks of glass containers in the hands of manufacturers at the end of March totalled 6,631,477 gross or 29 per cent less than the March 1942 figure. This was due to declines in all types of ware.

Automatic tumbler production during March amounted to 4,283,798 dozens, which was an increase of 2 per cent over February's figure. Shipments during March amounted to 5,337,543 dozens compared to February's figure of 4,189,749 dozens—an increase of 27 per cent. Finished stocks of tumblers at the close of March totalled 6,870,261 dozens, a decrease from February's figure of 12 per cent. Cumulative figures for the three months of this year show shipments amounting to 13,310,405 dozens and production totalling 12,948,728 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine made table, kitchen and household glassware during March totalled 4,759,934 dozens which was 45 per cent higher than last year. During the

CURRENT GLASS CONTAINER PRODUCTION

(All Figures Are Gross)

	Production		Shipments		Stocks	
	Mar. 1943	*Mar. 1942*	*Mar. 1943*	*Mar. 1942*	*Mar. 1943*	*Mar. 1942*
Food Containers (Narrow Neck, Wide Mouth and Pressed Ware)	2,573,509	1,986,464	2,689,708	2,158,111	1,806,148	2,049,206
Pressure and Non-Pressure Ware	464,882	471,848	478,087	503,024	421,376	693,697
Beer Bottles	863,899	740,276	951,796	733,401	189,147	344,078
Liquor Ware	679,752	937,984	857,186	983,470	967,441	1,675,911
Medicine and Toilet Ware	1,792,981	1,817,430	1,906,242	1,805,847	2,153,891	3,227,114
General Purpose Ware	641,226	553,320	670,911	514,235	541,414	529,632
Milk Bottles	239,180	265,062	234,685	243,144	356,462	392,200
Fruit and Jelly Jars	277,717	135,894	334,292	106,351	166,857	499,094
All Other	28,228	27,006	31,550	24,948	28,741	47,322
Total Industry	7,561,374	6,935,284	8,154,457	7,072,531	6,631,477	9,458,254

12 months period ending March 31, 1943, sales of this ware amounted to 41,666,335 dozens or 5 per cent higher than in the previous comparable period.

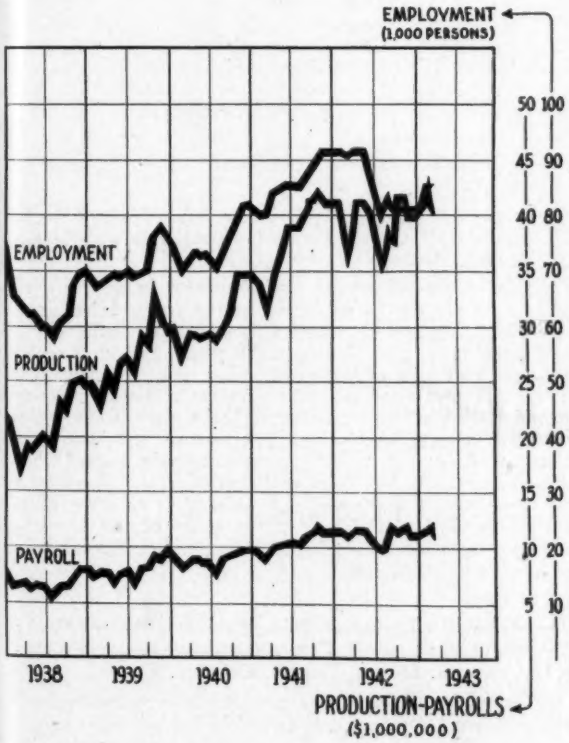
Miscellaneous glass products manufactured in February were valued at $16,000,000 according to reliable estimates. This was a slight increase over last year's total and the same as January 1943 figure. During the first two months of 1943 this branch of the glass industry had a production of $32,000,000, a slight gain over last year.

Employment and Payrolls: Employment in the glass industry during February amounted to 85,000 persons, the same figure as January of this year, but a decrease of 7 per cent from February 1942.

Payrolls in the glass industry during February are estimated at $11,500,000 as compared to $12,000,000 in January and $11,000,000 in February 1942. Glass manufacturers paid out over $23,500,000 in wages during the first two months of 1943 as compared to $33,000,000 in last year's corresponding months.

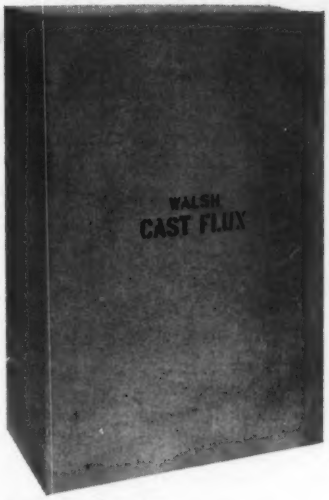
GI THE GLASS INDUSTRY'S INDEX

Monthly Trends Through February, 1943



• Dr. Alexander Silverman, Head of the Department of Chemistry at the University of Pittsburgh has been appointed Consultant on Glass to the Office of Production Research and Development of the War Production Board. His headquarters will be at the university.

WALSH CAST-FLUX



The Vacuum-cast flux block of superior quality.

Walsh Cast-Flux blocks are machine-trued to exact size and shape after burning.

THEY LAST LONGER

The excellent results obtained in numerous tanks melting various types of glass has definitely established the efficiency and economy of Walsh Cast-Flux blocks.

Walsh Cast-Flux has a dense, uniform structure; it is burned at higher temperatures, is thoroughly bonded and possesses a low coefficient of expansion.

Walsh Cast-Flux blocks meet the most rigid requirements for tanks operating at higher temperatures . . . they insure greater tonnage, higher quality glass, freedom from defects, longer life and maximum economy.

WALSH REFRACTORIES CORPORATION

Manufacturers of Refractories for the glass industry for over 50 years

4428 North First Street

St. Louis Missouri

RESEARCH DIGEST . . .

(*Continued from page* 214)

In the case of opaque glazes and bodies the stresses between the glaze and the body is measured by the means of a ring test, which, in brief, consists of measuring the distance between two reference marks on the upper surface of a test ring both before and after the ring is cut at a point between the two reference marks using a micrometer microscope for the measurements. If the ring expands it indicates that the glaze is in tension while if the ring contracts it indicates that the glaze is in compression. It seems quite possible that this glaze firing test could be successfully adapted to the measurement of the stress between glass enamel colors and dark colored or opaque glass such as decorated amber, black or opal glass.

GLASS TECHNOLOGIST

Wanted by Midwest research organization. Experience or graduate training in glass technology necessary. Write giving draft status and full details of training and experience. Box 62, The Glass Industry, 55 W. 42nd St., New York, N. Y.

Two Mixers for Sale: 1-3 Ton Traveling Car Mixer Drum Dimensions 6'Diameter, 4' Width; 1 T. L. Smith No. 148 Mixer—Known to the Building Trade as a one Batch Mixer, approximate Drum Dimensions 56" Hole to Hole, 45" Diameter. Rolland Glass Company, Clarksburg, W. Va.

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GLASS DIVISION . . .

(*Continued from page* 208)

Raw Materials. *By John R. Hostetter, War Production Board.*

A review of the functions of the Glass Unit of the War Production Board with an outline of the supply of raw materials used in glass making. This paper points out that while most of the raw materials used in the glass batch are not restricted as to end-use there are a number that are restricted or are under complete allocation. The restricted materials, although not handled by the Glass Unit, nevertheless pose a problem for this unit of the War Production Board since their essentiality, possible substitution or elimination fall within the scope of the Glass Unit. In connection with scarce or completely allocated materials Mr. Hostetter emphasized that every attempt is made to supply the restricted material provided it is for essential use. The Unit has no restrictive orders on types of glass produced but recommends that useful glass products be manufactured and that novelties and knicknacks be eliminated as soon as possible.

Some details were given as to the present supply situation of certain of the restricted or allocated materials. Specific mention was made of arsenic, cobalt, fluorspar, and nitrate of soda. Natural gas and the fuel situation in general was also briefly touched upon.

Incorporated in this address were the following statistics on the consumption of some of the major glass batch ingredients. During 1941 a total of 4,853,575 short tons of finished glass was produced. Some of the raw materials consumed were:

10,959	tons	Sodium nitrate
48,000	tons	Salt cake
3,131,788	tons	Sand
1,056,000	tons	Soda ash
630,341	tons	Lime and limestone
30,492	tons	Borax and boric acid
1,641,589	tons	own and foreign cullet
5,000	tons	potassium carbonate
6,554,169	Total	short tons

Structural Heterogeneity in Glass. *By Aniuta Winter (Mrs.): Institute of Optics, Paris, France (now with Research Eenterprises, Limited, Leaside, Ontario, Canada).*

Study of the mechanical strains present in a sample of glass does not enable prediction of the future behavior of this glass. There is no simple relation between such strains and the physicochemical state of the glass. In fact, it seems probable that most of these states may be obtained with or without birefringence, depending on the thermal treatment to which the glass was submitted. If the glass is not in the equilibrium condition for the temperature at which it is being used, it will transform spontaneously toward that equilibrium. The birth and evolution of strains depend on these physicochemical unbalances as well as on other characteristics of the glass. Only the study of the physicochemical state can give reliable indications of the behavior of glass in practical use.

Transformation Region of Glass. *By Aniuta Winter (Mrs.): Institute of Optics, Paris, France (now with Research Enterprises, Limited, Leaside, Ontario, Canada).*

Evidence for the existence of a "transformation region" rather than a "transformation point" in the 10^{14} poise range of glasses has been produced by a variety of experiments, both static and dynamic. Refractive index was measured (1) on small specimens quenched in air and (2) directly in the furnace by the single-prism and three-prism methods. Quantitative agreement was obtained, and the method of quenched samples is recommended as the simplest of those tested. Thermal expansion coefficients were also determined on the quenched samples.

Disannealing lowered the refractive index of glasses; for a borosilicate crown, by an order of 0.006. The change resulting from strains was comparatively small and in the opposite direction so the birefringence was found to be an untrustworthy indicator of the state of a glass. For a series of optical glasses, the difference between the refractive-index extremes is a function of the lowest temperature at which the minimum index can be realized. Thermal expansion coefficients may also vary with heat-treatment. Two limiting states of glass are postulated to explain the observations. In between these states lies the region of transformation, including an intermediate state for each temperature between the two limiting temperatures. For all of the glasses examined, the extent of the transformation region was about 100°C. The rate of transformation into the low-temperature state may be studied from "equilibrium curves" by plotting stable refractive index as a function of temperature. Whereas the conversion to the high-temperature state is instantaneous at the upper temperature of the transformation region, the conversion to the low-temperature condition demands a minimum time at each temperature, which explains why annealing is such a time-consuming process. The annealing time, however, may be drastically reduced by following the equilibrium curves in a stepwise fashion. With insufficient annealing, higher temperature states are frozen in and transformation continues even at room temperature, as proved by measurements extending over sixteen months of study.

REVISED WPB ORDERS IMPROVE POSITION OF CONTAINERS AND CLOSURES

Sweeping revision of the limitation orders governing the use of glass containers and metal closures were instituted through a series of amendments issued by the WPB during April. The over-all effect of the changes has been to greatly improve the position of the glass container as a packaging medium and to definitely encourage the use and conversion to glass for packaging wartime necessities.

In the amended regulations to L-103 of outstanding importance among the many important provisions are:

(1) Standard types of containers have been established, each type in several capacities. A user of glass containers now may select any style of container within his schedule, and any capacity that is not below the minimum set for his product. This constitutes a major reversal of policy and contrasts with the system initiated in Schedule C of the original L-103, where a specific container of specific capacities was designated for each product.

(2) Twenty-four types, 93 items, of foods may now be packaged in standard glass containers.

(3) Metal closure quotas have been liberalized, including those caps which require rubber, and for many products the quota within the scope of the order is unlimited. Food canners operating under can limitation order M-81 may substitute glass for their cans at a ratio of two caps for one can, and exceed the packing quota to that extent.

(4) Over-all quotas have been provided for specified drug products, and a manufacturer now may apply his quota as he wishes; that is, to all of his products, to part of his line, or to a single item.

(5) Inventories of empty new glass containers, whether in the hands of the glass manufacturer, in transit to the commercial user, or in the latter's own hands, are limited to 60 days requirements, unless the containers are to be used for most packing perishable products.

(*Continued on page* 228)

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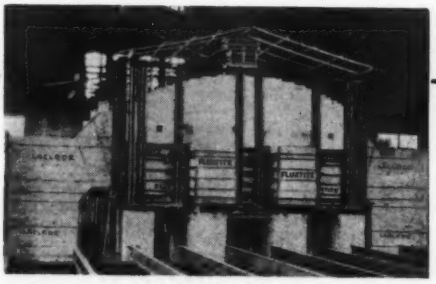

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(*Continued from page* 227)

Highlights of Amended L-103

Schedule A—Distilled Spirits: Six container designs are established.

Schedule B—Malt Beverages: Nine container designs are established. The single-trip beer bottle is limited to export use.

Schedule C—Foods: This schedule has been changed entirely. Formerly it applied only to preserves, jellies and fruit butters; now it includes 24 items. It should be noted that closure order M-104 also governs; for example, this order would prevent the use of a vacuum type jar for some products. Other new provisions of Schedule C includes: (1) deep screw caps are banned; (2) blown-in designs are forbidden; (3) small packers are exempt; (4) non-standard containers may be made until July 4, 1943 and used indefinitely thereafter; and (5) molds wearing out after April 5, 1943 must be replaced, if replaced at all, by standard molds.

Schedule D—Wines: No changes, other than to permit any type of finish to be used. The same nine containers remain standard as in the original schedule.

Schedule E—Protective Coatings: (Paste type paint). All restrictions have been removed on the use of wide mouth jars manufactured prior to Feb. 1, 1943 and in users hands by March 1, 1943. A new container has been added to the line of eight designated in the original schedule; namely, one with 136-oz. overflow capacity carrying an 89 mm. finish.

Supplementary Order L-103-a

This is a brief supplement to L-103 and was issued April 13. The essence of the order is contained in the following paragraphs:

Restrictions on suppliers. No supplier shall deliver to, or set aside for, any commercial user any quantity of any glass container which he knows or has reason to believe the commercial user is not entitled to accept pursuant to paragraph (c) below.

(*c*) *Restrictions on commercial users.* On and after April 18, 1943, no commercial user shall at any time accept, or have any supplier set aside for him, any quantity of any empty new glass container of any design and finish which will increase his inventory thereof to more than (1) two carloads; or (2) the total amount of his reasonably anticipated requirements therefor for the next 60 days, whichever is greater.

(*d*) Exceptions. The restrictions of paragraph (c) above shall not apply to any commercial user's acceptance, at any time, of any glass containers which: (1) were, on April 18, 1943, in transit to him from suppliers or set aside for him by suppliers; or (2) are for his use in packing fresh fish, fresh shellfish, fresh fruits, fresh vegetables, or products produced from fresh fruits or fresh vegetables. The term "fresh" refers to products which have not been previously preserved or frozen (temporary refrigeration in bulk excluded).

(*e*) *Applicability.* Any commercial user who uses glass containers at more than one plant may at his option, apply the inventory restrictions of paragraph (c) either to the inventory of each such plant separately or to the collective inventory of all such plants.

(*Continued on page* 230)

PRODUCTION OF ETHYL ALCOHOL SPEEDED BY GLASS FIBERS

Glass fibers again replace a vital material in rectifying columns for the distillation and production of ethyl alcohol. Before the war tinned-copper bubble plates and later burned-clay Raschig rings were used in the columns.

The new glass fiber packing material developed by the Owens-Corning Fiberglas Corporation not only is an excellent substitute for important materials but also actually speeds up the production of the 190-proof ethyl alcohol which is used for explosives, synthetic rubber and other war and essential civilian uses.

This increase in the rate of distillation of the alcohol is caused by the increased exposed surface area presented by the fibers as compared with the bubble plates or the Raschig rings.

ART DIVISION OF A.C.S. BECOMES INSTITUTE OF CERAMIC DESIGN

Reorganization of the Art Division of the American Ceramic Society was announced at the recent annual meeting of the Society in Pittsburgh. The Art Division will now be known as the Institute of Ceramic Design. While the functions and interests of this group will follow the established pattern the structure of the organization has been enlarged to provide for a representative from each industry in the Society. Walter A. Weldon heads the reorganized division as Chairman. Other industry representatives are: F. C. Flint, W. Keith McAfee, V. V. Kelsey, R. A. Weaver, Arthur A. Wells and Paul R. Belden.

BALL BOTHERS LAUNCH ADVERTISING CAMPAIGN

Ball Brothers Company has launched one of the biggest advertising and educational programs in their history to spread the use of their mason jars for home-canning. National advertising will be done in more than 160,000,000 advertisements in the larger women's magazines. More than 90,000,000 advertisements will appear in farm journals. Radio, publicity and motion picture film will be used for the other mediums, to help bring all-glass Ball Mason jars before the public.

The Ball company will stress their new glass top closure which supplements and replaces the metal caps used heretofore. These lids are said to be practical and dependable, and their quantity is unlimited.

POTASH ORDER M-291 FURTHER INTERPRETED

General Preference Order M-291 concerning Potash has been explained further recently that unless your company uses one of the four basic salts or run-of-mine potash, you will not be required to fill out form PD-600. The four basic salts of potash are: potassium oxide, muriate of potash, sulfate of potash, and sulfate of potash-magnesia. Run-of-mine potash is known as manure salts and kainit. The supplier is the only one who will have to fill out the form PD-600. He will consider his customer's requirements when filing his request for Potash with WPB.

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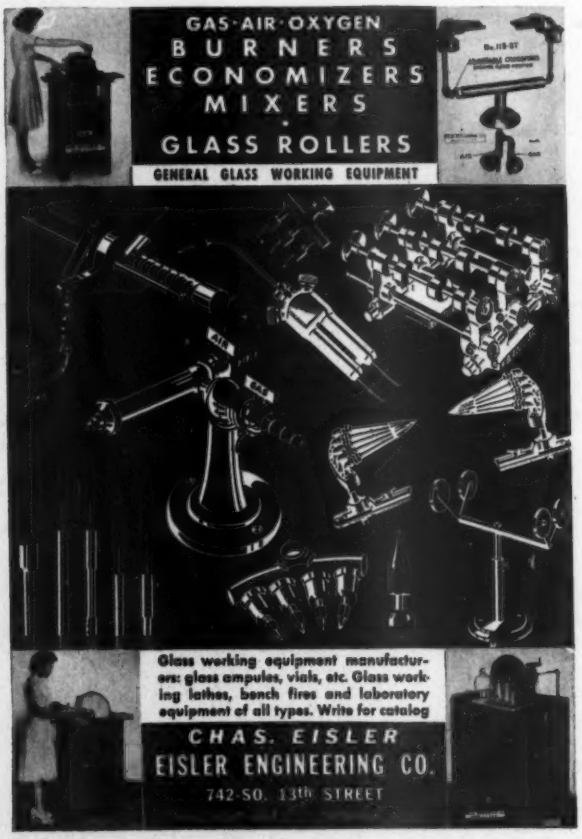
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(*Continued from page* 228)

Excerpts from Amended Order M-104

Schedule I—Food closures:

(A) Any person who used closures from Jan. 1, 1942 to Dec. 31, 1942, for packing a food product not listed in this Schedule I, may use an equal number of closures during the year 1943 for packing the products listed in this schedule, in addition to the quotas respectively specified.

(C) No product packed in a can shall be repacked for sale in a glass container, by the same or a different person, in the same or a different form, except to the extent specifically permitted in this schedule.

(E) Any person packing any product in cans during the calendar year or seasonal year who, because he converts such pack or part thereof from cans to glass containers, does not use the entire number of cans which he would be permitted under any limited quota specified in Order M-81, may use two closures for each can so not used. Such closures may be used in addition to the quotas established for any products by this Schedule I, but shall be made of the materials respectively specified.

Schedule II—Drug Products Closures: As already stated, the important change affecting drug products is one that provides over-all quotas. The total number of closures which may be used for packing specified products is 100 per cent of the number of closures and cans a manufacturer used in 1942. The quota may be used for any one, or for more than one of the specified products. Heretofore, the quota for one product could not be used for packing another product.

Bulbs or droppers for medicine bottles are excluded from the order.

Schedule III—Chemicals, Household and Industrial Supply Closures: Only two changes have been introduced into this schedule: The fungacide quota is increased to 135 per cent of 1942, and shaving cream is included for the first time. The latter has been given a quota of 100 per cent of 1942.

OWENS-CORNING APPOINTS DONOVAN STAFF EXECUTIVE OFFICER

To facilitate contacts between the company's executives and government agencies, Charles R. Donovan has been appointed staff executive officer of the Owens-Corning Fiberglas Corporation. He has been manager of the Washington, D. C., office and will retain his duties under the new set-up. This new position has been necessitated by the fact that Owens-Corning's factories now furnish almost their entire output under Army, Navy or Maritime Commission specifications.

GLASS PRODUCTS GIVEN PREFERENCE RATING UNDER CMP ORDER 5

All glass manufacturers except those making mirrors can now extend an AA-2B rating on all their purchase orders for operating and maintenance supplies, as outlined in CMP Regulation No. 5, according to information received by The Glass Industry. This interpretation gives the glassware industry a preference rating whereby they can secure operating and maintenance supplies at much less difficulty than if this Regulation had not been interpreted in their favor.

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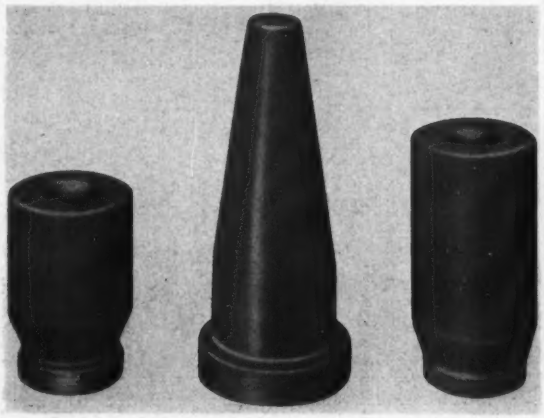

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